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(*Continued from p. 256*)

Afternoon Session, Friday, January 2, 1.00 p. m.

After the conclusion of the business, a number of papers were read.

PRESIDENT W. C. O'KANE: The first paper is "The Cornpith Weevil," by G. G. Ainslie.

THE CORNPITH WEEVIL (CENTRINUS PENICELLUS. HBST.)

By GEORGE G. AINSLIE, *U. S. Bureau Entomology, Knoxville, Tenn.*

In 1911 it was first noted that in Tennessee the upper two or three nodes of corn stalks are very commonly bored by a curculionid larva. Whenever possible since that time notes have been made on the insect doing this work and now when there is so much interest in corn stalk borers it will be well to set out the main facts in its life history.

The work, for it can hardly be called injury, is done by the larva of *Centrinus penicellus*, a small brownish-yellow rhyncophorous beetle whose host plant and life history have never been recorded. Dr. W. D. Pierce places the species in the genus *Geraeus* but Blatchley and Leng (1916) retain the name *Centrinus*.

The insect passes the winter as a milk-white larva curled in a small spherical cell in the earth. The first beetles make their appearance about July 1 increasing gradually in numbers until early August. Eggs are laid during this period and the larvæ feed through the rest of the summer reaching their growth and leaving the corn stalk for the earth about October 1. There is but one generation a year.

Blatchley and Leng give the distribution of the species as "New York to Iowa and Nebraska, south to Florida and Louisiana, scarce in southern Indiana." My information, so far as it goes, coincides closely with this. I have found the larvæ common in corn along the Ohio river from West Virginia to its mouth and in middle Tennessee and Kentucky the beetles sometimes become noticeably abundant. It is reported from numerous places in Maryland, New Jersey (Smith, 1910), North and South Carolina, Georgia, Alabama and Mississippi but I have failed to find it in Florida. Forbes and Hart (1900) record its distribution as "Atlantic states to the Rocky Mountains." Bruner (1891) records it from Nebraska. In addition, I have reports of what may prove to be this species from South Dakota. Just what factor it is that determines the northern limit of distribution is not known but it is suggested that it may be the depth to which the ground freezes during the winter. If this is true the species will work its way northward during a series of years with mild winters only to be thrown back by one with unusually low temperatures. An interesting observation in support of such a theory was made by Mr. C. M. Packard at a locality in Maryland where the elevation within 35 miles rises from 500 feet to 2,100 feet. At the lower altitude the species was abundant but higher up it disappeared entirely.

Fig. 8. — *Centrinus penicellus*, dorsal view.

Corn seems to be the main and most common food plant though larvæ which seem in every respect to be the same have been found in the stems of *Panicum crusgalli* and *P. dichotomiflorum*. It is very likely that other large grasses are also attacked. In one instance in middle Tennessee it was reported that millet grown for seed was being injured by a stem-boring curculionid larva and from the few immature larvæ I saw it is merely suggested that the work may have been that of this species. So far as our observations go it does not attack sorghum, broom corn or other closely related plants. On corn no injurious effects have been connected with its presence.

In corn the egg is laid in the main stem either in or immediately below the tassel. Even though the beetles are present no eggs are laid until the tassel is pushed out beyond the sheath thus exposing the culm. Very shortly, usually, after this has occurred the inconspicuous punctures of the beetles may be found on the stem but seldom or never on the tassel branches. The puncture is characteristic and unlike that made by any other insect with which I am familiar. It is elliptic in shape with its long axis perpendicular, open, about .20 mm. by .40

mm. in size, its margins often a little ragged and at first concolorous with the surrounding stem but soon darkening for a short distance back from the puncture. The number of punctures varies according to the abundance of the beetles and the length of time the stem has been exposed. Counts at several times and places have given the number from one to eleven per plant, the average between four and six. Not all of these are egg punctures as many seem to be made for feeding purposes only. Externally the two are indistinguishable. I have never seen the punctures elsewhere than on the upper part of the stem and in the tassel but Mr. E. H. Gibson reports that in Mississippi the beetles commonly feed on the midribs of the leaves where the tissue is of much the same character as in the stem.

Fig. 9.—*a*, Section of corn stalk just below tassel, showing egg punctures; *b*, Section with sheath removed to show exit hole of larva.

In making the puncture the beetle stands transversely on the stem and after cutting through the bark consumes enough of the pith to form a small cavity which always lies to the side of the opening, never above or below it, indicating that the beetle does not rotate while feeding as do many rhyncophora. The operation requires from thirty minutes to an hour to complete and if it be a female preparing for an egg she then steps forward, presses the tip of the abdomen to the puncture and inserts the egg. When in situ the egg lies in the pith a millimeter or more from the outside surface and usually distorted from the unequal pressure. The egg is so soft that its shape is never twice alike. It resembles nothing so much as a bit of water-clear jelly. When freed from pressure it is oval or elliptical in outline, sometimes a little flattened or slightly reniform, or almost cylindrical, .670 to .699 mm. long and 0.40 to 0.42 mm. broad, considerably larger than the puncture through which it enters. The chorion is very tenuous and without markings save for small accidental wrinkles.

As development proceeds the egg becomes milky and a day or two before hatching the brown mandibles can be seen through the chorion. One egg whose deposit was observed on July 22 had not hatched when dissected from the stalk on July 29 but the mandibles were plainly visible so the egg stage is probably but little over a week. After the nidus is once opened it is difficult to keep the egg from drying or molding for more than a day or two.

The hatching is nothing more than a rupture of the delicate membrane inaugurated and assisted by the mandibles which can sometimes be seen slowly opening and closing before the membrane breaks. The

membrane once ruptured and pushed aside, the head slowly changes to brownish yellow and the minute grub begins to feed on the delicate pith cells surrounding it. It turns at once downward and cuts a straight passage so small at first as hardly to be visible. The exact number of instars has not been accurately worked out. It would seem that this could be determined from the head casts left in the burrow and occasionally one of these can be found but after the first or second instar the larva becomes more active and instead of continuing directly downward it constantly moves up and down in the burrow enlarging it and crushing any exuviæ into hopeless bits. I have made head measurements of a large number of alcoholic larvæ but the sizes grade imperceptibly into one another, making any separation on this basis impossible.

When the larva reaches the first node it pauses for some time either because the septum is harder to cut through or because the tissue just at the node is more succulent and attractive. In either case the node seems to be a favorite resting place and quite a cavity is cut out and partially filled with the fine, fluffy, pale yellow frass. When a stalk is opened the larva, in the majority of cases, will be found in or near this nodal cavity. Between the nodes the larva continues the burrow as a clean straight tunnel, a little wavy in direction but seldom with branches or side passages. Close to the egg puncture and also at the nodal cavities, the passage is somewhat discolored, yellow or brownish, elsewhere perfectly white and clean. The presence of the larvæ is most easily determined by a smooth cut between the first and second nodes from the top when the passage, if present, appears as a clean round hole. I have thought that in some cases I could locate infested plants by external examination and it may be that the tassels and the upper nodes of infested plants become brown and dry a little sooner than the others but this method is not certain. In no case have I observed from the work of this insect any breaking over of the tassels, but an instance of this was noted at Hagerstown, Md., September 29, 1919, by Mr. C. M. Packard. Broken tops were found, many of them on infested plants, but as not all of the broken stems were infested it is hardly possible to attribute the condition to this insect alone. As these broken-over tassels are one of the most conspicuous evidences of the work of the European corn borer (*Pyrausta nubilalis*) further observations on this point are desirable. As each node is reached the larva delays and enlarges a cavity there. Occasionally the larva completes its growth at the top node, more commonly at the second and third and only very rarely does it reach the fourth node from the top.

Although very often more than one egg is laid in a single plant it is very unusual for more than one of the larvæ to reach maturity. All

others seem to be crowded out or starved by having no fresh pith to work in. Whenever two or more larvæ do persist for a time the pith is completely riddled with burrows and changed to a mass of finely granular frass.

In Tennessee most of the eggs are deposited late in July and early in August, and two months later, about October first, practically all the larvæ are mature. It is surprising how simultaneously the larvæ in any given field mature and leave the stalk. It has repeatedly happened that in a field where scarcely an exit hole could be found one day, only an occasional larva could be found a day or two later. In middle Tennessee this general exodus occurs very near October 1. In almost every infested field a few larvæ can be found in the stalks a month or more beyond the usual emergence date but such larvæ are generally smaller and immature. They are either larvæ hatching from very late laid eggs and without sufficient time to feed to maturity or those starved by the premature or rapid drying of the pith as the plant ripened or was killed by frost.

The burrow ends, usually, at or near a node, sometimes running an inch or two below it. The exit hole may be at a node or anywhere between but the most usual place for it is just above a node, within an inch or two of it. This would seem to be a rather unsatisfactory point for the ensheathing leaf base often so tightly enfolds the stem that the larva to escape must cut its way through both the stem wall and the leaf sheath. In rare instances the sheath of the leaf below also overlaps this one so there are three tough walls to be cut before the larva is free. Often, however, after cutting through the stem wall there is space enough behind the leaf sheath for it to escape in which case the exit hole is not visible until the leaf base has been removed.

The emergence hole is not round but more often distinctly oblong, with its long axis parallel to the stem, about .75 mm. wide and 1.50 mm. long. The hole appears too small to permit the passage of the satiated larva but observation shows that if the head emerges the body can follow. The edges of the hole are often not clean cut. The exit hole, like the egg puncture, is characteristic of this species and once observed can hardly be mistaken.

There is nothing especially noteworthy in the rest of the life cycle. The larvæ simply wriggle free from the corn plant, fall to the ground and enter the soil at some crack or irregularity. In dense soil they go down but three or four inches, in a cultivated field or in mellow ground from eight to ten inches, often below the furrow slice. One was found in the center of a large clod lying on the surface. After reaching a sufficient depth the larva by rotation forms a smooth compact-walled, more or less spherical cell in which it lies awaiting the time of pupation the following summer.

As larvæ have never been carried entirely through their transformations under observation neither the exact date of pupation nor the length of the pupa stage is known.

All my notes and all the collection records to which I have access show that the beetles make their appearance first about July 1. From this time on they slowly increase in number, reach their maximum early in August and then gradually disappear. They have been taken as late as September 30 in Tennessee and Kentucky.

In the field the beetles are rather difficult to capture. They are always alert and at the least disturbance take wing almost as readily and quickly as a fly. When cornered they feign death and drop instantly but take flight after falling a few inches. During the day in clear weather they remain usually partly hidden among the leaves and in the throat of half grown corn plants, coming out to feed and oviposit toward dusk and on cloudy days.

The percentage of infestation even in neighboring fields varies considerably and may reach practically 100 per cent. The date at which the corn tassels emerge seems to be the determining factor, the very late planted corn being almost entirely free of larvæ. It does not seem possible to plant early enough to avoid their attacks for the earliest tassels to appear are at once attacked. It is probable that many of the beetles emerge before that time and feed sparingly on various plants while awaiting their favorite food.

References in literature to the biology of this species are few and unimportant. It was described in 1797. Bruner (1891) lists it among insects found attacking sugar beets. Riley (1893) notes that occasionally the beetles feed on green corn kernels. Forbes and Hart (1900) report its work on sugar beets as injurious. Hunter and Hinds (1905) list it among the insects mistaken for the boll weevil and note that the beetles are found in flowers. Pierce (1907) lists it but adds nothing new to its biology. The adult is fully described and its distribution given in some detail by Blatchley and Leng (1916). It seems very strange that it has been overlooked by Forbes and his workers in their exhaustive studies of corn insects for it must occur at least in southern Illinois.

The only natural enemy of this species so far observed is a minute cecidomyid, the salmon-yellow larvæ of which enter the egg punctures, feed on the eggs and sometimes perhaps even attack the small grubs. These predators have been repeatedly observed in the burrows in Tennessee and Mr. P. Luginbill sent me from Columbia, S. C., a partially grown beetle larva very evidently killed by the maggot which was still feeding upon it. This one was reared and developed into a delicate midge with banded wings. It has not been determined.

I quote herewith the description of the adult given by Blatchley and Leng (1916):

"Oval or subrhomboidal, feebly flattened above. Piceous-black, densely clothed with narrow, pointed, dull yellowish scales, those of thorax arranged transversely, those of elytra forming two or three nearly regular rows on each interval; each elytron usually with three submarginal dark spots on apical two-thirds, one or two of these sometimes almost or wholly wanting; beak, antennæ, tibiæ and tarsi dark reddish-brown. Beak slender, compressed, half as long as body, finely striate-punctate on sides, polished and almost impunctate above. Antennæ inserted just beyond basal third; second joint of funicle slender, nearly as long as the next two, the latter equal. Thorax one-fourth wider than long, sides feebly converging from base to middle, then broadly rounded to near apex, which is subtubulate; disc densely and rather coarsely punctate, slightly carinate at middle. Elytra at humeri distinctly wider than thorax, thence narrowed to the conjointly rounded apex; sculpture hidden by scales. Length 3.5-3.8 mm."

DESCRIPTION OF LAST INSTAR LARVA BY A. G. BOVING

Family Characters

Larva hypognathous (with mandibles directed vertically ventrad and posterior end of cardo attached near the occipital foramen). Body subcylindrical, soft skinned, with deeply plicate segments; three thoracic and ten abdominal segments present; tenth abdominal segment small, wartshaped. Legless. Labrum free, movable. Mandibles without molar part. Maxilla with single large maxillary lobe; stipes behind maxillary lobe united with a large, fleshy, simple subfacial area which is continuous with prothorax. Buccal cavity without hypopharyngeal chitinization. Tentorium forming a broad and strong bridge.

Generic and Specific Characters

Head somewhat inserted into prothorax; cranium, when liberated, slightly longer than wide. Epicranial suture half as long as cranium; lateral epicranial carina curved, viewed from above subparallel with outline of cranium, extending posteriorly to end of epicranial suture; each epicranial half with six setæ, arranged as shown in fig. 10, 4. Ocelli two, first ocellus anterior and inferior, placed near antenna, twice as large as second, posterior and superior ocellus, the position of which is about midway between first ocellus and lateral epicranial carina (fig. 10, 2). Frons about as long as epicranial suture; frontal sutures diverging about 120°; strong median frontal carina; three small setæ on anterior frontal margin, two long and one small setæ on frontal plate, arrangement and relative size as shown (fig. 10, 4). Antennæ very small, two jointed, basal joint not much higher, but considerably wider than apical joint, with five small setæ and one sensorial puncture (fig. 10, 6). Clypeus transverse, about four times as wide as long, glabrous. Labrum transverse, anterior margin convex, extreme length medianly about as long as clypeus, width about three times greater than length; dorsal face of labrum (fig. 10, 4) on each side with three long, slender setæ; anterior marginal face (fig. 10, 1) on each side with a lateral group of three setæ and a median group of two; ventral face or epipharynx on each side with two setæ, one anterior and thick, the other posterior and fine and placed inside anterior end of epipharyngeal rod. Mandible subtriangular (fig. 10, 1) somewhat larger at base than apically; inside concave, gouge-shaped; distally with five teeth, external tooth on each side small; one small seta. Maxilla with glabrous cardo; stipes proper carrying one long seta (fig. 10, 7); palpiger with two setæ of different length; single maxillary lobe (or mala) ventrally with five well-developed setæ (fig. 10, 7), dorsally, toward buccal cavity with seven

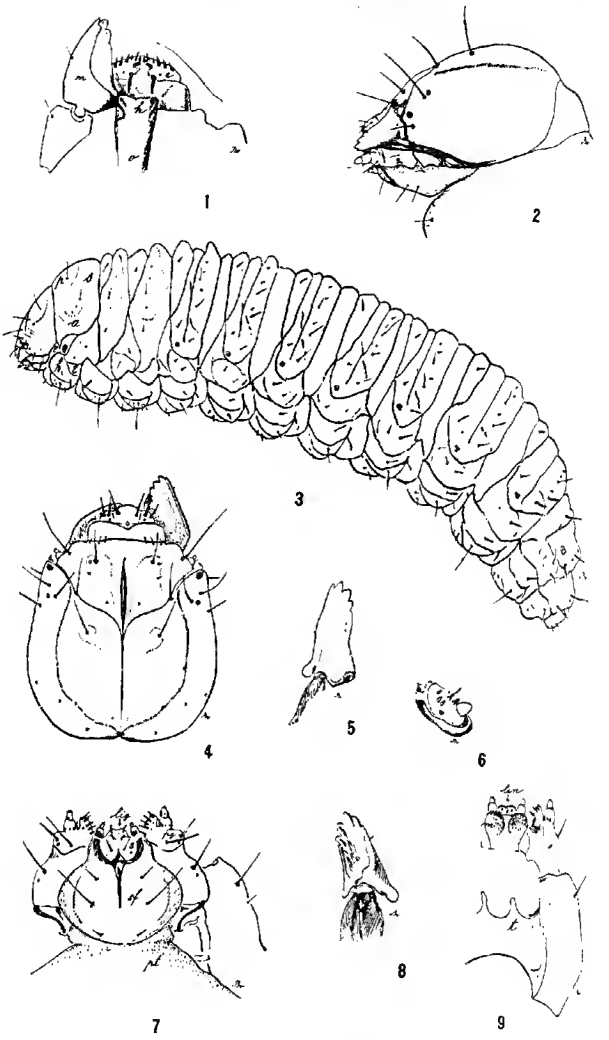

Fig. 10.—1, *e*, epipharynx; *h*, hypopharynx; *m*, mandible from below; *o*, œsophagus; 2.—lateral view of head; 3.—side view of larva; 4.—dorsal view of head; 5.—mandible, lateral, exterior face; 6.—antenna; 7.—*c*, cardo; *l*, ligula; region of fused ligula and lingua; *pg*, palpiger of maxilla; *pl*, prothoracic skin; *s*, stipes labii; *sf*, subfacial region formed by fused mentum, submentum and articulating area of maxilla; 8.—mandible, buccal, interior face; 9.—*lin*, lingua-region of fused ligula and lingua; *m*, maxillular region; *t*, tentorium.

somewhat shorter and thicker setæ (fig. 10, 9); maxillary palp short, with two articles, basal article a little longer and about twice as wide as the apical which is conical and about as long as wide; basal article with one short seta and two sensory punctures, apical article finely papillose at the tip, one sensory puncture. Stipes labii (s. fig. 10, 7) fleshy, with one seta, posteriorly limited by a curved chitinization, the posterior end of which is amalgamated medianly with an unpaired, spear-shaped longitudinal chitinization. Ligula and lingua (lig. fig. 10, 7 and lin. fig. 10, 9) fused into a short, slightly bidivided lobe; ligula region with one well-developed seta, lingua region with one minute seta. Maxillulæ (m. fig. 10, 9) lobe shaped, densely setose. The undivided subfacial area (sf. fig. 10, 7) is probably formed by a fusion of the mental, submental and the maxillary articulating areas; it carried three pairs of setæ, the position and size of which is shown in figure 10, 7.

Thorax. Prothoracic tergum simple with the different tergal areas very slightly indicated; prescutal region with one seta (p. fig. 10, 3); scuto-scutellar region with one distinct and two very small setæ (s. fig. 10, 3); alar region with one seta (a. fig. 10, 3). Meso-and metathorax with two tergal pleats, one formed by præscutum, and the other by scuto-scutellum and alar area; præscutum with one seta; scuto-scutellus with one distinct seta and two very small setæ below and one very small seta above this; alar area with one seta. Prothoracic epipleurum (e. fig. 10, 3) small, consisting of a triangular, glabrous preëpipleural area and a triangular glabrous postepipleural area, both above hypopleurum (h. fig. 10, 3) and separated from this area by the ventro-lateral suture; questionable if the spiracle carrying area belongs to prothorax; more probably to be interpreted as a separate part of the mesothoracic preëpipleurum. Mesothoracic preëpipleurum anteriorly pushed forward into prothorax and separating the spiracle carrying area from the prothoracic postepipleurum, large triangular, with three setæ; mesothoracic postepipleurum triangular, glabrous, placed above the mesothoracic hypopleurum. Metathoracic praeëpipleurum triangular, bidivided, each division with one seta; metathoracic postepipleurum triangular, glabrous. Metathoracic, rudimentary spiracle not observed in the present species. All thoracic hypopleural as well as sternal areas similar in position, shape and size. Thoracic hypopleurum situated below ventro-lateral suture, semioval, with one distinct seta; an additional very small seta on prothoracic hypopleurum. Thoracic presternum wanting in front of each thoracic segment; eusternum large, unpaired, triangular, with one seta on each side of body's middle line; parasternum or coxal lobe, representing the leg, triangular, with one large and four small setæ; sternellum wanting; poststernellum transversal, bandlike, with small median notch, glabrous.

Abdomen. The first seven abdominal segments almost identical in every respect; the three last segments somewhat modified and reduced. Abdominal tergum divided into four main pleats, corresponding to prescutum, scutum, scutellum, and postscutellum; second pleat indistinctly divided into a median dorsal part, scutum proper, and a lateral part; likewise the third pleat, divided into a median, dorsal part, scutellum proper and a lateral part; the two mentioned lateral parts are fused around the spiracle, together forming an area which corresponds to the alar area of the thoracic segments. Prescutum with one seta; scutum proper glabrous; scutellum proper with five setæ transversely arranged in proportion to the length of body, two of which are large, two small, above, and one small between the large setæ; division below scutum proper with one seta and division below scutellum proper with one; postscutellum glabrous, functioning as articulating (or intersegmental) skin. Epipleurum ventrally limited by ventro-lateral suture; median region slightly indicated, bearing two setæ; preëpipleural region subtriangular, dorsally reaching end of prescutum, glabrous; postepipleural region correspondingly shaped but not extending so far dorsally as preëpipleurum, glabrous. Hypopleurum dorsally limited by ventrolateral

suture, semioval, with one seta. Presternum wanting; eusternum unpaired, subtriangular, with posterior apex in middle line of body, two setæ on each side; parasternum or coxal lobe paired, triangular, with anterior margin oblique, inner angle pointed and meeting the corresponding angle of parasternum of the opposite side of body, one seta; sternellum wanting, possibly fused with poststernellum; poststernellum transversal, bandshaped, glabrous, functioning as articulating skin. Eighth abdominal segment somewhat smaller than the preceding typical abdominal segments, with areas less distinct, arrangement and number of setæ typical. Ninth abdominal segment half as large as eighth, areas not developed, with two large and two small dorsal setæ and one large ventral seta. Tenth abdominal segment small, wart-shaped, with terminal round anus, two small setæ. Spiracles before, small; thoracic spiracle pleural, placed right below the lower margin of prothoracic tergal region, about twice as large as the following seven abdominal spiracles, its finger-shaped air tubes directed upwards; all abdominal spiracles with air tubes directed backwards, eighth abdominal spiracle as large as the thoracic and placed slightly more dorsal than the other abdominal spiracles. Size; about 9 mm. Color; whitish with light brown chitinous parts.

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MR. W. D. PIERCE: I think Mr. Ainslie is to be greatly complimented on this paper. Biologists have been puzzled many years to know how these insects lived. We have had our suspicions but no one has been able to work them up. I do not think the common name that has been given this species is sufficiently definite because there are other beetles that breed in cornstalks. It is interesting to know that this particular species extends throughout our Southern States and Central America, and probably South America.

VICE-PRESIDENT E. C. COTTON: The next paper is "Notes on the Habits of *Calendra pertinax* Olivier," by A. F. Satterthwait.

NOTES ON THE HABITS OF CALENDRA PERTINAX OLIVIER[1]

By A. F. SATTERTHWAIT, *Scientific Assistant, U. S. Bureau of Entomology*

One of our common and most widely distributed billbugs, *Calendra*[2] *pertinax* Oliv. (Pl. 5, fig. 2), breeding normally in the common cat-tail

[1] Published by permission of the Secretary of Agriculture.

[2] *Calendra* Clairville and Schellenberg, 1798, Ent. Helv., p. 62, takes priority over *Sphenophorus* Schönherr, 1838, Gen. et Sp. Curc., vol. 4, p. 874, according to Dr. W. D. Pierce, in Proc. Ent. Soc. Wash., vol. 21, no. 2, Feb., 1919, p. 26.

(*Typha latifolia* L.) and Calamus or sweet flag (*Acorus calamus* L.), deserves closer attention than it has had for a decade or two. Its economic prominence is based on its destruction to corn. The species was described by Olivier in 1807. During the century following, various records of heavy corn losses were connected with this name until, in 1905, Dr. F. H. Chittenden recorded the fact that one specimen that was reared about 35 years earlier had been incorrectly determined as *C. pertinax*. This specimen had been taken under circumstances which made this species appear to be the offender involved in heavy corn losses in an important agricultural area over a period of many years. With *Calendra pertinax* separated from that line of economic records, a certain distrust creeps in concerning other records, even though the determination of the insect may have been correctly made.

As for distribution, since the confusion of this insect with *C. robustus* Horn and *C. maidis* Chttn. has been eliminated, we may consider distribution summaries published by Dr. Chittenden in 1905 and by others since that date, correct, so far as known at the date of publication. Dr. Chittenden in 1905 recognized the distribution of *C. pertinax* as extending from New York City to Utah, and south as far as Washington, D. C., south of which point the typical form did not appear to have been taken. From Louisiana, Texas and Kansas, and possibly Arizona, he had a different form, for which he erected the new varietal name *australis*, and from California and Nevada, another form which he called the variety *typhæ*. Messrs. Blatchley and Leng, in "Rhynchophora of the North Eastern United States," 1914, stated that *C. pertinax* occurs in Northern Indiana, about New York City, throughout New Jersey and at Orlando, Florida, with the range from New England and Canada to Michigan and Utah, and south to Florida.

The writer has taken the species at Athens and West LaFayette, Indiana, and at Advance, Charleston, Sulphur Springs and Webster Groves, Missouri, and has been privileged to include in his studies, material from Hagerstown, Maryland, through the kindness of Mr. C. M. Packard, from Flushing, New York, through the generous coöperation of Mr. E. L. Bell throughout the season of 1919, and through the kindness of Mr. J. H. Jenkins and of Dr. J. L. Cook, of Advance, Missouri. This opportunity is taken to thank also the members of the staff, Messrs. H. R. Painter, R. A. Blanchard, C. Bagby and B. S. Reid for their valued assistance in the work, and Mr. W. R. Walton for helpful criticism of the manuscript. Taking each locality separately, we will consider first,

The Situation at Flushing, New York

While making a study of *Sphida obliqua* Walk., Mr. E. L. Bell, of Flushing, N. Y., made an incidental report on *Calendra pertinax* to

the New York Entomological Society, revealing a different mode of wintering than has been observed by the writer. Upon request for data and infested host plants, Mr. Bell responded very generously and has supplied the writer with numerous collections of stalks of the common cat-tail (*Typha latifolia* L.) at representative intervals throughout the year, with pertinent notes on water levels in relation to the plants submitted.

In his letter of April 17, 1919, Mr. Bell wrote in part as follows: "The specimens that I collected were taken this year on March 1 and 8, except one adult specimen taken on February 22, and included one larva, several pupæ in different stages, and adults. So it would seem that this species does not hibernate in adult form, but rather pupation occurs in the late fall or winter, and the adults emerge in the spring. Most of the specimens were collected in a low part of the swamp that is always flooded in the winter and spring, and at the time they were collected, their position in the stalk was at least a foot under the water, but they did not seem to be in any way harmed by it. They seemed to run somewhat to colonies, as in some places every stalk contained from one to four beetles or pupæ and in other places close by but an occasional specimen or none would be found."

Dr. S. A. Forbes, in his Eleventh Report, pages 17 and 18, stated that Dr. Kellicott repeatedly reared this species to the imago in July and August from larvæ and pupæ found in New York in the common cat-tail; and that Professor Parrot, relating to Nebraska insects, assumed that *C. pertinax* wintered over in the pupa stage, as he had received some specimens in May, 1898, some of which had the peculiar pinkish color characteristic of beetles just emerged from the pupa. This Nebraska observation appears to agree well with Mr. Bell's New York observations this spring. Dr. Kellicott's observation agrees well with Mr. Bell's observations and collections this summer, and with the writer's observations in Indiana and Missouri.

Under date of April 28, Mr. Bell wrote that they had had several days of unprecedentedly cold weather just preceding April 26, when he collected a number of cat-tail stalks which he believed contained pupæ and adults from a portion of the swamp where the water was several inches more than knee-deep, the swamp being very full of water from recent heavy rains. He examined cat-tail stalks that grew on the edge of the swamp where it was drier and found some stalks that had contained *C. pertinax*, but no billbugs were present in them.

This collection of April 26 was received April 30. There were 15 stalks in the collection, each stalk and root crown and the only piece of rhizome in the collection showing larval work. There were 25 larval excavations, 20 or 21 containing exuviæ, 2 dead larvæ, 6 dead pupæ and

4 male and 2 female *C. pertinax* adults, all dead, and one of each sex imperfect. From this collection it appears that all pupation takes place in the stalks, at least in cat-tails constantly in water, the larval excavations terminating at varying distances above the crown, as if the insect instinctively sought for a pupation place above the normal water level. Of these 25 excavations, 20 or 21 appeared completed, judging by evidences of the transformation from the larva to the pupa in all but 4 or 5. These excavations ranged above the crown as follows: 1 at 2 inches, with the adult specimen dead in a position indicating effort on its part to escape by cutting out of the plant; 5, between 3 and 4 inches; 7, between 4 and 5 inches; 3, between 5 and 6 inches; 4, between 6 and 7 inches; 2, between 7 and 8 inches; 1, at $8\frac{3}{4}$ inches; 1, at $11\frac{1}{2}$ inches; 1, height not noted. Those with excavations reaching more than 7 inches above the crown all escaped successfully. These numerous dead specimens probably were drowned by the unusually high water catching them while they were immature, those dying in the adult stage being weakened by submergence while yet pupæ. During summers, the water drains away from this area and the cat-tails stand on moist soil.

On June 29, Mr. Bell collected nine stalks of cat-tail from this same swamp. They were received for study July 3. On this date 14 eggs and 18 larvæ were found and 3 feeding punctures of adults were observed. When the collection was made, June 29, the water had disappeared, though the soil remained soft and spongy.

The next collection was made in the same area August 10, at which time there was about 8 inches of water present, the result of heavy rains of the preceding three weeks. This collection was received on the 13th and examined on the 13th and 14th. There were 16 stalks. The living specimens found were 6 eggs, 14 larvæ and 4 pupæ, and the dead specimens were 2 eggs and 11 larvæ. There were several larvæ in a soft, white condition, strongly indicating that these were drowned, leading to the conclusion that the flooding of the cat-tails had been the chief cause of mortality. Six male and 5 female *C. pertinax* adults were successfully reared from this collection, 1 being adult October 6 from an egg laid prior to the collection of the stalks on August 10. The other adults issued on August 19 and September 6 and on intervening dates.

The next collection was made September 6, at the same place as previously, with the water level just where it was August 10,—almost knee-deep. He observed that almost every cat-tail stalk in this locality contained larvæ, with some stalks so full of them that there was only a thin shell left, and they broke off at the root when the attempt was made to pull them up. This collection was received September 12

and was examined the next day. There were 12 stalks, each one showing larval excavation. One adult male *C. pertinax*, 2 live pupæ and 1 living and 3 dead larvæ were secured, a small representation as compared with earlier collections, probably partly the result of the decay of the specimens which, four weeks ago, would have been visible, and partly the result of some considerable percentage of the survivors, as observed in the collection of August 10, having matured and escaped. One adult female *C. pertinax* was reared from 1 of the pupæ on September 19.

The next collection was made September 21, Mr. Bell choosing another section of the swamp which is not covered with water, though quite damp. The cat-tail growth here is not so heavy as in the portions covered, the plants standing somewhat separately in a heavy growth of various kinds of vegetation. In this soil the plants would not pull up, so were cut off somewhat below the surface of the ground. While making the collection, Mr. Bell saw larvæ, pupæ and adults of *C. pertinax* in some stalks. He searched in the soil about the plants and found no evidence of any larvæ leaving the plants to pupate in the soil. This collection was received for study September 24, and consisted of 19 stalks. Of these, 18 contained a total of 23 *C. pertinax* larval excavations, and only 1 was unaffected. In the 19, there were 4 stalks containing *Sphida obliqua* larval excavations, both insects working in common in 3, 1 of these 3 stalks containing burrows of two *Calendra* larvæ and the larvæ themselves. One *Sphida* excavation contained a pupa shell of the moth. There were also 2 prepupæ, 6 pupæ, 6 male and 1 female *C. pertinax* adults, 1 hymenopterous parasite cocoon with a *Calendra* larval mask attached in the larval excavation. In checking up as to place of pupation for the makers of these 23 larval excavations, 2 specimens were prepupæ, 6 were pupæ, 5 were adults, 9 left their exuviæ in their cells in the stalks, escaping as adults, and 1 was destroyed by a parasite while in the larval stage. Thus, the fact that pupation at Flushing occurs in the cat-tail stalks, even in those plants not in standing or flowing water, is well established. From 1 of the pupæ, an adult male *C. pertinax* issued September 26.

On October 13, Mr. Bell made a collection in the water and in the soil areas, in the same swamp as before, keeping each collection distinct for comparative study. These stalks were all cut off, rather than pulled up with crown and possible roots. In the water area there was not nearly so much water as on the occasions of the collections of August 10 and September 6. Mr. Bell observed that all the stalks he sent lacked flower stalks and always have been shorter than the uninfested stalks, except of course the young shoots. In the series of 12 stalks from the water area, there were 22 burrows, 16 dead larvæ, 2

dead pupæ, 2 hymenopterous parasite cocoons, 5 adult exit holes, and a lost top to 1 larval excavation, the top having been removed in the swamp. Of these, 10 larvæ and 1 pupa appeared to have been drowned. Thus, of 23 specimens actually accounted for,—18 dead and exits presumably of at least 5 adults,—about 8 per cent of the mortality is parasite, about 48 per cent apparently drowning, 22 per cent not accounted for, and only about 22 per cent of the brood successfully matured. So far as life permitted, pupation in this series was entirely within the plants. The series of 12 stalks from the portion of the swamp not water-covered showed 16 burrows, 3 dead larvæ (2 killed by hymenopterous parasites but none apparently by drowning), 2 living and 3 dead pupæ (1 killed by a hymenopterous parasite), 2 adult female *C. pertinax*, 3 hymenopterous parasite cocoons and exits presumably of at least 5 adults. Only 1 of the 12 stalks showed a portion of a crown. Had the complete crowns been secured, more excavations and possibly, though improbably, some evidence of soil pupation might have been found. Thus, of 15 specimens actually accounted for,—6 dead, 4 living and present, and exits presumably of at least 5 adults,—60 per cent have matured or probably will mature successfully, with 20 per cent mortality attributable to parasites and a like mortality to undetermined causes.

In conclusion to the study of the *C. pertinax* habits in the Flushing, N. Y., conditions, it may be stated that pupation has occurred invariably in the cat-tail stalk, at or near the top of the larval excavation, that adults developed in the swamp as early as September 6, and in cages as early as August 19 from a pupa collected August 10. In the collections of October 13, 1919, of 38 specimens accounted for in 24 stalks, 12 adults had matured fully and only 2 remained immature, these 2 being pupæ with a fair possibility of maturing before winter. Numerous eggs were present August 10, 1919, while pupæ were present, indicating a possibility that some might not mature before winter, hence explaining the condition that Mr. Bell found at Flushing in March, 1919, when larvæ and pupæ, as well as adults, were present. One point accomplished in the long egg-laying period of *C. pertinax* is the avoidance of the obliteration of a colony by any probable single rise of water level. Eggs laid from the middle of June to the middle of August are likely to be laid in part at every normal water level, while, in the event of the water level rising only after the last of the eggs have been deposited, those first laid at low water levels will have had time to mature and the adults escape.

The Situation in Indiana, Maryland and Missouri

The places in Indiana, Maryland and Missouri from which *C. pertinax* used in this study have been collected are West LaFayette and

Athens, Indiana, Hagerstown, Maryland, and Advance, Charleston, Clinton, Meramec Highlands, Sulphur Springs and Webster Groves, Missouri.

At West LaFayette, Indiana, a number of common cat-tails growing in a small seepage swamp on a hillside on the east side of South Elsworth Street, and separated from the Wabash River by a half mile of cultivated bottom land, were examined on October 29, 1915. A number of stalks showed larval work, but only 1 good larva was secured. This larva, in the root crown in which it was found, was placed in a tin cage and kept in a warm room. By November 2, it had left its excavation. By November 18, it had pupated and by the 23rd, had become an adult male *C. pertinax*. Undoubtedly if this specimen had remained in the swamp, it would have wintered as an immature specimen, probably as a larva. Investigations of cat-tails in this swamp were continued November 27, when several excavations packed characteristically with frass, with occasional larval masks, were found, and 1 dead adult *C. pertinax* was found in its larval excavation, above a wad of frass representing one end of the pupal cell. The larval excavation extended some inches along the horizontal root stock or rhizome.

On July 14, 1916, the billbug situation in a field two miles northwest of West LaFayette, where possibly 10 acres of land had gone back to swamp, was made the subject of study. As the result of a neglected tile drain, water was constantly present in such quantity that water fowl bred there. Cat-tails were abundant some distance out in the water. The river bulrush (*Scirpus fluviatilis* (Torr.) Gray), was perhaps the dominant possible billbug host actually growing both in the water and on the shore. The land around the pond was covered with a dense sod, mostly of *Cyperus strigosus* L. The evidence of billbug work is frequently hardest to find where the host plant is extremely abundant. It so happened, however, that in this large bed of *C. strigosus*, 1 female *C. pertinax* adult was taken, clinging head downward as if feeding, on a plant of *C. strigosus*, about 1 inch above the roots. In her cage, this female fed freely on the plant.

About a mile east of Athens, Indiana, a collection of common cat-tail root crowns infested with *C. pertinax* was made in a mud hole along the north side of the Erie Railroad, when the mud was stiff enough to walk on. About 25 per cent of the crowns were infested, some with 2 or more larvæ to the crown. Two larvæ were nearly or quite mature, some were quite small. From this collection, 17 *C. pertinax* adults, including 5 males and 11 females were reared, mostly in an outdoor, 10-inch flower pot cage. This cage was examined October 18, at which time 13 adults, 7 pupæ and 1 diseased larva were found, some in pupa cells in the soil, and no specimen and no exuviæ belonging in pupa cells were found in any of the larval excavations in the crowns.

At Hagerstown, Maryland, Mr. C. M. Packard collected 8 larvæ boring in the bases of stems of the common cat-tail in the City Park swamp, July 25, 1919, and sent them to the writer for study. From these larvæ, 2 male and 1 female *C. pertinax* adults were reared, 1 adult issuing August 5, and 2, August 25.

At Charleston, Missouri, the collection places were beds of common cat-tail in dredged ditches at the east and west edges of town. The surface soil in the vicinity of the ditches is sandy, with sand modifying a limited part of the cat-tail areas studied, gumbo being the chief soil encountered in the ditches. The condition of the soil seemed to make no difference in the degree of infestation, or in habits, though plants constantly in water at the head of the east ditch were examined and no infestation found. Larvæ proving to be *C. pertinax* by rearings, were collected in excavations in cat-tail stalks close to crowns, in the crowns and in the rhizomes, and in the soil about the roots, and pupæ were collected in the soil about the roots, but only once in plant tissue. This exception was a pupa found in a cell in a leaf-sheath slightly over 2 inches above the crown and embracing a stem which, after 3 days' shrinkage, had a minimum diameter of 26 mm., or more than an inch. This pupa was injured and the species was not confirmed by rearing, but appears certainly to be *C. pertinax*.

The collections at Charleston may be briefly analysed by dates, as follows:—

August 13, 1918, 22 larvæ and 1 pupa, maturing 2 male and 3 female *C. pertinax* from larvæ collected in rhizomes and 2 females from conditions not specified, also 1 male *C. minimus* from larva in rhizome and 1 female *C. melanocephalus*, conditions not specified.

September 3, 8 larvæ, maturing 1 male *C. pertinax* from larva in soil and 1 male *C. minimus* from conditions not specified.

September 9, 10, 11, 13 larvæ and 8 pupæ, maturing 1 male and 1 female *C. pertinax* from larvæ in root crowns, 1 male and 2 females from larvæ in rhizomes, and 3 males and 7 females from larvæ and pupæ in soil, also 2 female *C. minimus* and 1 female *C. melanocephalus* from larvæ in soil.

September 21, 1 larva, 2 pupæ and 1 male and 1 female *C. pertinax* adults, maturing 1 male *C. pertinax* from conditions not specified.

September 23, 4 larvæ, 5 pupæ and 1 adult female *C. pertinax*, maturing 1 female *C. pertinax* from larva in rhizome, 1 female from larva in soil, and 1 male and 2 females from conditions not specified.

September 24, 1 larva, 3 pupæ and 2 adult male *C. pertinax*, maturing 1 male and 1 female *C. pertinax* from larvæ in soil.

September 28, 7 larvæ, 9 pupæ and 4 adult female *C. pertinax*, maturing 1 female *C. pertinax* from larva in root crown, 1 male and 1 female from larvæ and pupæ in soil, and 3 females from conditions not specified.

As insufficient data have been assembled for the separation of the immature forms of the several species of *Calendra*, and as 8 species, 2

of which have been bred from cat-tails and 2 from soil at the base of cat-tails, in the east ditch, the larvæ have been grouped under *C. pertinax* or under other species on circumstantial evidence, the size of the immature form being an important guide, as small *C. pertinax* larvæ have no occasion to be in the soil, and small larvæ in the cat-tail are presumed to be small *C. pertinax*. Thus, in the supposed *C. pertinax* list of 56 larvæ and 28 pupæ, 12 male and 25 female *C. pertinax*, 2 male and 2 female *C. minimus* and 2 female *C. melanocephalus* were successfully matured, fixing an accurate basis of determination for scarcely more than half of the immature collections.

At Clinton, Missouri, Mr. Painter found 1 pupa in soil about the roots of common cat-tails growing in a small bed in soft, wet mud, not water-covered, near the artificial lake in a pleasure resort west of town, October 17, 1918. This pupa changed to an adult *C. pertinax*.

At Advance, Missouri, in a recently drained peat area of about 1,200 acres, known as the "Big Field," 4 miles east of town, common cat-tails were growing abundantly May 23, 1919, and were heavily infested with *C. pertinax*. Corn was grown on this portion of the "Big Field" in 1918, but at this time was not through the ground. Numerous adults were taken in their feeding punctures in cat-tails (Pl. 5, fig. 1, and many eggs and some newly hatched larvæ were found in the leaf-sheaths. The eggs were laid in the cells of the leaf-sheath (Pl. 5, fig. 3), the cells being larger than the eggs for a considerable part of the width of the encircling sheath. Rarely, an egg was found between sheaths. As none of the eggs or larvæ collected in the Advance area were reared to maturity, no record of associated species was made, except that of 85 adults taken by Mr. J. H. Jenkins, Mr. H. R. Painter and the writer on June 4 and 9 and May 23, respectively, 83 were *C. pertinax* and 2 were *C. scoparius* Horn. (See plate 4.)

At Webster Groves, Missouri, eggs of *C. pertinax* were first found June 17, 1919, in cells in the leaf-sheaths of common cat-tails growing in a low area south of the Frisco Railway tracks, a short distance west of the depot. This area is completely free from water part of the year. On September 26, Mr. R. A. Blanchard collected 4 adult *C. pertinax* in soil under a cat-tail plant in this low area and 1 adult clinging to cat-tail roots about 1 inch below the surface of the soil in a similar area

Plate 4.—A view in the "Big Field," Advance, Mo., looking northeast across damaged corn. Much damage was done to the corn by *Calendra pertinax* Oliv., the most common host plant of which is the Common Cat-tail (*Typha latifolia* L.), abundant in this part of the "Big Field." Retarded growth of the corn when 3 or 4 inches high accentuated the damage. The height of vegetation is indicated by the camera case, 14 inches high, at the right. Photographed June 9, 1919, by Mr. H. R. Painter.

1

2

3

in Sherwood Forest, north of the railroad and about a half mile west of the first area. This latter area probably holds water throughout the year, and is being filled with cans and ashes. Both areas are in openings in oak groves, on clay soil.

At Meramec Highlands, Missouri, a few miles west of Webster Groves, on July 18, 1919, Mr. Painter collected 16 eggs and 4 larvæ, supposedly of *C. pertinax*, in common cat-tails in a small cat-tail pond in a wheat field. An adult female *C. pertinax* was reared from each of 2 eggs, the larvæ being reared in sections of corn stalks, 1 adult issuing September 27, the second, the following day. Rearings attempted in timothy were failures.

At Sulphur Springs, Missouri, the common cat-tails examined cover possibly an acre of wet, flat land a half mile west of town. A very small stream of sulphur and of magnesium spring water courses through part of it, while most of it is without a water cover during the summer. Trees margin the swamp except at the west end, where a wheat field borders the swamp at the top of a bench, 1 to 3 feet above the floor of the swamp. At first visit, July 29, 1919, the writer collected 1 *C. pertinax* pupa about 1 inch deep in the soil, 4 larvæ supposed to be *C. pertinax* in cat-tail crowns, and 1 smaller, apparently mature, larva in soil where there was no water, at edge next to the wheat field. Various cat-tail crowns were collected at the same place for subsequent study. These, examined August 7, produced 8 larvæ and 1 pupa. From the larva collected in the soil and noted as too small for *C. pertinax*, 1 adult female *C. zeæ* Walsh was reared. From the 4 supposed *C. pertinax* larvæ collected in crowns in the field, 2 adult female *C. pertinax* were matured and 1 pupa was so nearly adult that it was identifiable as a male *C. pertinax*, and from those collected in crowns subsequently examined, 6 adult *C. pertinax*, including 2 males and 2 females, were reared.

On September 16, Mr. Painter collected plants from the northern, eastern and central parts of the area, the eastern border alone being watery, a narrow stream, scarcely 1 inch deep and about 1 to 2 feet wide, flowing across. The water level at the eastern end is almost at the surface of the ground. In the western part, the water level was

Plate 5, 1.—*a*. Feeding punctures of *Calendra pertinax* Oliv. adults in stalks of Common Cat-tail, Advance, Mo., May 23, 1919. These excavations are comparable to gnawings of small rodents, and in some instances two adults were about half buried in a single feeding puncture when found. *b*. Scars typical of egg punctures. Photographed by Mr. H. R. Painter;

2.—*Calendra pertinax* Oliv. Adult female, enlarged 6 X. Photographed by Mr. H. R. Painter.

3.—*Calendra pertinax* Oliv. eggs in situ in natural cells in leaf-sheath of the Common Cat-tail, Webster Groves, Mo. Photographed by Mr. H. R. Painter.

not within 6 inches of the surface. In the east and central part of the area, 1 mature larva was collected at the base of a plant, 1 pupa in a plant at the surface of the ground, and 2 in plants at points about 4 inches above the surface. From 1 of the last 2, 1 male *C. pertinax* was reared.

In the western part of the swamp, 3 larvæ, 3 pupæ and 1 male and 3 female *C. pertinax* adults were taken, in conditions as follows: 1 larva in base of a cat-tail plant 4 inches below the surface of the soil, which subsequently produced a female *C. pertinax* adult; 1 larva in base of plant 2 inches below the surface, which afterward produced an adult male *C. pertinax;* 1 larva in base of plant 3 inches below the surface, which died; 2 pupæ in soil 2 inches below the surface, which subsequently produced 2 adult female *C. pertinax;* 1 pupa (position not noted), which was crushed; 1 adult male *C. pertinax*, in cell, probably the pupa cell, in soil, 1 inch deep; and 3 adult female *C. pertinax* on the surface of the soil, among cat-tails.

This series shows a definite tendency to pupation in the stems, the trait appearing in 3 instances recorded above, with soil pupation in like number of instances, as observed September 16, 1919.

Viewed in their relation to water or excessively wet soil, there were the 3 examples of stem pupation and 1 of soil pupation, in the 3 pupæ and 1 prepupa taken at the east and central portion of the swamp where the stream and the water level were about at the surface of the soil. This provides a 75 per cent example of stem pupation where too much water prevails at the base of the plants, but no tendency was observed in this direction among the specimens taken where the soil was several inches above the water horizon. On July 29, at the western end, where the soil was firm, only 1 specimen was taken in so advanced a stage as a pupa, and this was in the soil, outside of its host plant.

The Economic Aspects

From the economic standpoint, the preceding notes show that the common cat-tail, a widely distributed swamp plant, is subject to liberal infestations by *Calendra pertinax*, an insect which, under favorable conditions, may prove very destructive to corn. These notes are based on 12 cat-tail areas represented by 9 post office centers, in 3 states. The writer has only one other record of cat-tail area examined, at Mt. Pocono, Pennsylvania, where a brief examination was limited to a small clump of plants rather remote from the open water. No evidence of *C. pertinax* work was found, but this negative record is not dependable. It is anticipated that all cat-tail beds are more or less infested with *C. pertinax*, and to be regarded accordingly as a menace to corn in every case where cat-tail sod is broken for corn.

The writer's first opportunity for studying the injurious work of *C. pertinax* on a large scale in the field, was in the "Big Field" area near Advance, Mo. (See plate 4.) In response to a general billbug questionaire, Mr. J. H. Jenkins, whose farm lands include several hundred acres of this recently drained, treeless tract, stated, under date of April 26, 1919, that he had a 25 per cent loss on 100 acres of Reed's Yellow Dent corn, securing only 50 bushels of corn per acre as first crop on new land which was plowed in 1917 and cropped first in 1918.

On May 23, the writer called on Mr. Jenkins, who was, at the time, unable to go to his farm. As his brother, Mr. E. B. Jenkins, had similar land and a greater billbug loss in 1918, this latter farm was visited. The field where the losses were so prominent on this farm, was particularly free from weeds, grasses and sedges, and thus without host plants for billbugs. It was stated that the condition during the corn growing season of 1918 was as now, no grasses or weeds being allowed to grow. It was further stated that this land was submerged in May, 1918, when a certain diversion canal bank gave way at the head of the drainage district as a result of an extraordinary flood. This overflow undoubtedly brought in and deposited whatever billbugs were involved in the destruction of the corn.

Mr. Jenkins stated that there were wild grasses on the J. H. Jenkins farm, some two miles north, and similar wild plants on the J. L. Cook farm lying between.

Dr. Cook's farm was visited at a point in the open area a short distance east of the tenement house which is situated in the woods. The peaty soil here is very subject to ignition from bonfires, and is of such a character that one may shake the surface for a possible radius of 50 yards. Large wooden shoes are attached to the feet of horses and mules used in the "Big Field" to keep them from sinking too deeply into the soil.

Wild iris occurred sparingly and showed no billbug infestation, but the common cat-tail was rather abundant in patches and *Calendra pertinax* adults were found on a heavy proportion of the stalks, with feeding and egg punctures in nearly all. In a little while, 15 adults and numerous egg-infested stalks were collected for study at the laboratory. The feeding holes of *C. pertinax* in cat-tail stalks are largest at the stalk surface, usually as wide as the width of the adult. They are sometimes circular and sometimes twice as long, up and down the stalk, as wide, and occasionally deep enough for more than half of the adult to be within the contour of the stalk. It is similar to the gnawing work of a small rodent. (Pl. 5, fig. 1.) The egg punctures are without excavation, a slit being cut through the outer surface of a leaf-sheath or, if deeper, through one more outer than inner surface, and

the egg deposited in a natural cell. (Pl. 5, fig. 3.) Rarely, an egg was found deposited between leaf-sheaths. Several eggs are frequently found in a single leaf, some leaves in this collection having four.

On May 29, Mr. J. H. Jenkins wrote of the "Big Field" as open marsh land, formerly covered with tall grass, some of it growing to a height of 15 feet. Of his corn, he writes: "I am having considerable trouble with my corn on this land and hardly think that the trouble is due entirely to billbugs. The corn comes up and grows to 3 or 4 inches in height, then turns yellow. Some stalks die and others finally grow out, later in the summer, but not in time to make an ear. Pumpkins and turnips, in the same locality where the corn dies, make a fine crop."

On June 4, Mr. Jenkins wrote again concerning his corn. His tenants were complaining considerably, which led him to make a personal investigation. His letter, in part, is as follows: "I find that most all of the blue flags have the billbugs, usually from one to as many as six on each plant, and I find some injury in the corn resembles the billbug injury in the flags. However, in the infested places all the corn looks bad, the leaves cut and wilted, and of a yellow color. On some of the corn plants I can find the effect of the bugs and can find some bugs on the corn plants, but on other plants that look just as bad, I cannot find any sign of the bugs. I have about 300 acres of corn planted. Of this amount, I have about 50 acres that now looks like it will be a total loss, as the corn is turning yellow and dying. I planted some over last year and the second planting did about as bad as the first planting. I have made a pretty close study of this trouble and I am impressed that there is some cause other than billbugs, such as lice, ants or gnats. I found a few chinch bugs today, however, not enough to cause any material trouble. The water level is very close to the surface, which fact makes it appear to me that, if the land was tiled, there would be less of the above named insects. I find also quite a lot of green gnats and green insects like lice, which may account for the leaves of the corn being withered and eaten as you will see from the samples I am sending you in today's mail. . . . In selecting this corn today, I pulled up all the damaged plants in the row, in order that you could see that some of the plants had the sign of the bugs and that some did not show the place of injury. I found most of the bugs I have in the sack with the corn on blue flag. However, I found some bugs on the corn plants. I found two worms that had entered the corn plants at the root and worked out all the center of the plant."

The letter, specimens of injured corn and the insects were received June 5. The billbugs collected on blue flags and corn were *C. pertinax*, 2 males and 10 females. As blue flags occur in the "Big Field," they

may have been the host plant in this case, but on May 23, the writer found no billbugs nor billbug work on the isolated blue flags then examined, while the cat-tail was very heavily infested. The two worms that had worked in the centers of two corn plants mentioned in Mr. Jenkins' letter, were referred to Mr. George G. Ainslie for determination. Under date of June 10, Mr. Ainslie reported these as *Crambus praefectellus*, a species of root web-worm usually taken singly, hence not usually a serious pest. There was 1 adult *Diabrotica 12-punctata*, but as none of its work was recognized on the corn leaves, it is probably not seriously involved. No lice, ants or gnats were found. Some of this shipment of corn plants were forwarded to Washington for pathological examination, but were spoiled before reaching their destination.

On June 2, Dr. Cook sent to the laboratory a package containing 5 corn plants. This package reached its destination June 6, broken open. No living insects remained with the corn. The partial remains of a male *C. pertinax* were found. The corn plants were crippled and showed punctures typical of *C. pertinax* adult work. The crowns also showed discoloration of the same type as did those from Mr. Jenkins.

On June 9, Mr. Painter visited the "Big Field," examining the billbug infested fields of the Messrs. Jenkins and of Dr. Cook. He agrees in his observations with Mr. J. H. Jenkins in the conclusion that there is insufficient drainage. He found the water level was within about 8 inches of the surface of the ground and the whole area practically of the same level throughout. He found cat-tails quite prominent (see Plate 4), and cane grass (probably *Arundinaria tecta* (Walt.) Muhl.), rather plentiful, in various parts of the field. *Calendra pertinax* was abundant at this time in cat-tails. In a portion of Dr. Cook's field, Mr. Painter secured 6 male and 12 female *C. pertinax* adults and, while collecting these, took 2 female *C. scoparius* adults, 1 on corn and 1 on cat-tails. While this would indicate that *C. pertinax* represented only 90 per cent of the billbug infestation, the consideration of all adults taken by Mr. Painter where corn was growing in the "Big Field" on this date, 20 male and 37 female *C. pertinax* and 2 *C. scoparius*, the fair portion of the billbug damage chargeable to *C. pertinax* would be slightly over 96 per cent.

In summing up the relationship of *C. pertinax* to the corn loss this year and accepting the statement of the gentlemen pecuniarily interested in the corn, that the conditions we saw this year were the same as prevailed last year, the writer is disposed to charge *C. pertinax* with about 95 per cent of the insect damage to the growing corn plants, and the insect damage about 90 per cent, and direct water damage in some possible depressions, 10 per cent. The close proximity of water to the surface of the soil undoubtedly is a disadvantage to corn in this

"Big Field" at times, depending on the height of the water table and upon the temperature of the soil. How much damage is due to the presence of water and how much to the billbugs must remain a matter of opinion, but the water damage appears to the writer to be essentially a halting of the growth of the corn during the higher level of the water or during the unfavorably cool weather, especially when the corn is up only 3 or 4 inches, as mentioned by Mr. Jenkins, in letter of May 29, for 1918 and 1919. Such conditions probably cause some yellowing of the foliage without killing the plant or reducing the yield. Incidental to the halt in the growth of the plant, the work of any insect will have an intensified deleterious effect, provided the conditions retarding growth in the plant do not equally retard the insect. As *C. pertinax* is a swamp grass insect, the retarding effect of water on the adult is negligible.

Referring to Mr. Jenkins' description of the corn injury, as seen June 4, we have this statement: "In the infested places all the corn looks bad, the leaves cut and wilted, and of a yellow color." Mr. Painter observed the condition of the leaves on June 9, and says the perforated appearance of leaves typically injured by billbugs was lost, and the leaves of many plants were blown to ribbons, with no apparent explanation. These observations so well represent extreme billbug injury to corn foliage as seen at Charleston, Mo., in 1917, where the damage was done by *C. callosus* Oliv. and *C. destructor* Chttn., both smaller species than *C. pertinax*, that the leaf condition is accepted as adult billbug work, 96 per cent *C. pertinax*.

Dr. Forbes, in his Eleventh Report, states that the plant injured by *C. pertinax* is less frequently killed outright than by *C. aequalis* Gyll., a larger species, but is commonly dwarfed, often becomes badly twisted as it grows, and rarely forms an ear. Mr. Jenkins, in his letter of May 29, describes this injury when he writes that "some stalks die and others finally grow out, later in the summer, but not in time to make an ear."

A report from Mr. Jenkins, received December 16, 1919, after he had studied the corn damage throughout the season and harvested the corn, includes an estimate that the billbug damage was 80 per cent of the insect damage and the major part of all the damage. He considers that the wetness of the season and of the soil caused the corn to come to a stand still, making the work of the insects more disastrous. He has already laid considerable tile, which will improve the drainage. The plant he referred to earlier as blue flag he now reports is cat-tail, on 1 plant of which he collected 8 billbugs. Some of the corn made a good yield, about 80 bushels per acre, while some was almost a failure. The area damaged in 1919 was less than in 1918, when the damage was very heavy.

In this area, improved drainage will help the corn to grow steadily and will help the land operators to destroy the billbug host plants. The breaking on this tract was done the year before the first crop was planted, which was good. Summer breaking gives the quickest results in destroying billbug host plants. If they are completely destroyed before winter, any surviving billbugs will leave, and corn can safely be planted the following spring. Where the destruction of host plants is only partial, the planting of corn will be attended with such losses that a diversity of crops not susceptible to billbug injury, such as pumpkins, turnips, melons, flax, cotton and beets, might and probably would be more profitable. Such crops planted in rows and cultivated would allow as rapid destruction of the host plants as would corn. Usually billbug injury ceases to be serious after the second crop has been produced on new land where the host plants have been abundant. These losses, however, may be eliminated completely or may cover several years, depending directly upon the time the host plants are completely destroyed.

MR. E. G. KELLY: Have you found the larvæ of this insect in corn?

MR. A. F. SATTERTHWAIT: No. The injury to corn that I have found was caused by the adult.

VICE-PRESIDENT E. C. COTTON: The next paper is "The Green Clover Worm on Soy Beans," by Franklin Sherman, Jr.

THE GREEN CLOVER WORM (PLATHYPENA SCABRA FABR.) AS A PEST ON SOY BEANS

By FRANKLIN SHERMAN, *Entomologist State Department Agriculture, Raleigh, N. C.*

On July 29, 1919, the farm agent of an eastern county in North Carolina wrote us of a worm destroying leaves of soy beans. Within a week complaints were coming by the dozen. Larvæ were identified at Washington as *Plathypena scabra* Fabr. the Green Clover Worm, one of the "Snout-moths" of the family Noctuidæ (broad sense), and we were told that it had become epidemic simultaneously from New England to Florida.

Within ten days the injury was at its height, within two weeks it was on the decline and some fields were recovering,—but also in less than a week from the first complaint a preliminary survey had been made, and we had two temporary Field Stations in operation, one by the writer at Elizabeth City and the other by Mr. Leiby, assistant, at Terra Ceia.

Our special studies extended from August 1 to September 10, covering the last of one brood of larvæ, through the pupal, adult and egg stages, to the point where the next generation of larvæ were about one-fourth grown. While most of the facts here given are from the writer's own work, Mr. Leiby's notes are also used as mentioned from time to time.

The Life-stages

Our findings on the duration of the several stages agree well with the accounts of Coquillett in Canadian Entomologist July, 1881,—Chittenden in Bulletin 30 U. S. Division Entomology 1901,—Britton in 8th Report Entomologist of Connecticut 1908,—and Hill in Farmers Bulletin 982 U. S. Department Agriculture, 1918.

Eggs collected in the field hatched within 4 days,—those laid in Mr. Leiby's cages in five days.

From hatching to spinning of cocoon is given as 25 days by Coquillett, which we take to be normal in mid-summer.

We both recorded that after spinning the fragile cocoon the insect remains as a larva for two days. We have not found mention of this in the literature.

The true pupal stage varied from eight days *plus* to 14 days and a fraction,—*eleven days* being the most common and also the average, we give it as the true normal for the time and place of our observations.

From August 17 to 22, the writer placed in one cage with suitable foliage and water, reared moths as follows: six males, thirteen females, and six of undetermined sex. Only one certainly laid eggs and these eight days after the last male had been removed, dead. Mr. Leiby had similar results under same conditions, but secured eggs more freely when molasses was lightly smeared on the leaves, on which he observed both sexes to feed. He also found the moths to live a week or more before laying eggs. It seems certain that mating takes place soon after emergence and that a week must then elapse before eggs are laid, the moths feeding in the meantime.

Summary:

Egg	5 days
Hatching to spinning of cocoon	25 days (*Fide* Coq.)
Larva in cocoon	2 days
True pupal stage	11 days
Emergence to mating	1 day
Mating to laying of eggs	7 days
Total	51 days

The winter is normally passed in the adult stage, as proven by numerous collecting records in our own state and elsewhere.

Habits

Hill, referring to outbreaks in alfalfa, says the eggs are laid on the under side of the leaves and are hard to find because their color matches the leaf. On soy bean we found the very fresh eggs to resemble the leaf, but as they approached hatching they were darker, the chief difficulty in finding them being their small size. We did not find a preference for the lower side of the leaf. In a close examination of 1,600 leaves August 27 to September 1, we found 62 eggs on upper surfaces to 45 on lower surfaces. As an evidence that the moths disperse far and wide before laying, eggs were found as numerous where the larvæ had been fewest, as where they had been most abundant.

The larvæ can spin a weak thread and young ones often suspend by it. They are active and when disturbed can contort so violently as to throw themselves several feet. As one farmer wrote—"he flops like a cat-fish." They crawl with a semi-looping motion. They are green, variable. In our cages as well as in the field very young larvæ showed a preference for the under side of the leaf and did not eat all the way through, but within three days, by the time they devoured an area as large as our copper cent, they ate entirely through and were to be found as numerously on the upper as on the lower surfaces. These observations refer to the larvæ on soy-bean, especially on the younger leaves. I am aware that others have found that on lima bean they are more prone to remain on the lower surface and to feed only on that side, leaving the upper epidermis intact.

Having observed the feeding habits both in cages and in the field we can say that even when present in great number the injury is not conspicuous for the first fifteen days of larval life, but becomes greatly emphasized during the last ten days.

When grown the larvæ drop from the plant or wander, often being found on weeds upon which they apparently did not feed. They pupate on or just under the soil in cracks, crevices, accidental holes or under trash, in loose silken cocoons mingled with particles of earth.

The adults fly actively, show an inclination to seek shelter around buildings, and are only indifferently attracted to light. The males average larger than the females, indeed the sexes were regarded as distinct species until proven identical by Lintner in Canadian Entomologist, May, 1873.

Natural Enemies

The only definite records we find under this head in the literature are in Chittenden's paper where two species of parasites are recorded, neither of which were found by us.

At Elizabeth City on August 14 the writer entered in his notes with reference to the then maturing brood of larvæ, that bacterial disease had killed many and might be a factor with the next brood; that perhaps 25 had been seen affected with fungous disease, not over two had been seen giving evidence of internal insect parasites, and that one paper-nest wasp (*Polistes* sp.) had been captured in the act of devouring a larva.

Rearings from 77 collected pupæ at Elizabeth City by the writer gave a total of 54 moths and 3 parasites. Fifty-six larvæ caged when grown or nearly so yielded 20 moths and no parasites.

At Terra Ceia Mr. Leiby secured a higher percentage of parasites from the pupæ.

When eggs began to appear rearings from these were begun and here was found the most important parasite factor at both stations. Approximately 50 per cent of the eggs turned to a dull black and yielded the egg-parasite, *Trichogramma pretiosa*, determined by Mr. Crawford at Washington.

A cage was started by the writer with 19 eggs collected in various parts of the field: 10 young larvæ hatched; two egg-shells were removed without finding larvæ, while the other seven eggs yielded 12 specimens of *T. pretiosa*.

Four cages operated by the writer contained eggs which appeared to be parasitized. These resulted as follows:

(Cage 1) 3 eggs of *P. scabra* yielded 7 specimens of *T. pretiosa*
(Cage 2) 8 eggs of *P. scabra* yielded 11 specimens of *T. pretiosa*
(Cage 3) 7 eggs of *P. scabra* yielded 12 specimens of *T. pretiosa*
(Cage 4) 1 egg of *P. scabra* yielded 3 specimens of *T. pretiosa*

The largest number of *T. pretiosa* reared from a single egg of the host was three. Mr. Leiby accomplished the same result at Terra Ceia. It is plain that the emergence of two adults of the parasite from one egg of the host is common, and that three is not rare. These findings give to *T. pretiosa* the undisputed first place among the parasites of the green clover worm on soy beans in eastern North Carolina in 1919.

The second parasite in importance was the Tachinid, *Phorocera claripennis*, of which Mr. Leiby reared 17 specimens at Terra Ceia, none being secured by the writer at Elizabeth City. It may here be noted that in our state this fly is the second most prevalent parasite of the true army-worm, which was in evidence where these studies were made.

The writer and Mr. Leiby each reared one specimen of the Tachinid, *Exorista boarmiæ*, and Mr. Leiby reared one each of *Frontina aletiæ* and *Euphorocera floridensis*. Of other flies the writer reared one of

Sarcophaga cimbicis and Mr. Leiby one of *Anthrax lateralis*. The writer also reared one hymenopteron identified by Mr. Cushman at Washington as "a *Campoplegine* apparently new species and new genus."

This gives a total of eight species, none heretofore recorded from this host so far as known to us. The list follows:

1. *Trichogramma pretiosa* Riley, a very important egg-parasite.
2. *Phorocera claripennis* Macq., moderately important.
3. *Exorista boarmiæ* Coq.
4. *Frontina aletiæ* Riley.
5. *Euphorocera floridensis* Tns.
6. *Anthrox lateralis* Say.
7. *Sarcophaga cimbicis* Tns.
8. A *Campoplegine*, probably new sp. new gen.

Field Conditions

To appreciate the economic problem presented to us, a brief description of field conditions is necessary. The outbreak was universal throughout the eastern half of the state: tens of thousands of acres of soy beans in the aggregate were so defoliated that the lace-work of dried leaf-veins gave a hazy cob-webby appearance to whole fields. In the most severe cases all foliage was eaten, but normally the attack was most severe on the younger of the grown leaves in the upper part of the plant, leaving the growing bud and the older lower leaves. This enabled many fields to make quick recovery when the worms were killed, or after they had matured. The larvæ were feeding so ravenously and growing so rapidly that every day, each hour, was important. It was a case of immediate action or a lost opportunity. Hence the cage work and field observations which have been mentioned were carried on simultaneously with field tests of remedies and publicity work.

With us the soy bean crop is grown in either or all of four ways (1) in rows to itself, (2) in rows between rows of corn, (3) broadcast in fields to itself, or (4) broadcast between rows of corn. We immediately recognized that whatever direct remedies were to be used could be more effectively applied where the crop was in rows by itself, and that to meet the other conditions would be more difficult.

Experiments with Remedies

We find no previous record of definite tests with arsenicals, these have been ignored as out of the question in field areas, and we were further hampered by the general reputation of beans for susceptibility to injury by their use. But it was evident that nothing less than an immediate application of arsenicals could save the situation. We

decided to advise dusting with dry powdered arsenate of lead one pound to eight pounds of dust lime, or liquid spraying with one pound to 25 gallons water, using machines in either case, or if necessary applying the dust by hand. This advice was sent to all county agents, and to the press through the extension service. We then set to work to prove the efficiency and safety, or otherwise, of this advice.

Among the tests was one in which a plant was dusted lightly by hand with the one to eight mixture, paying no special attention to the lower sides of the leaves; the plant was caged and ten nearly grown larvæ were placed on it. This cage was started by the writer at 6:30 a. m. August 8, the cage being carefully "floored" with white paper to facilitate finding any larvæ which might drop. By the 12th (in four days) seven of the larvæ had died; by 8:30 a. m. August 14 (in six days) eight had died with all the symptoms of poisoning, one had died of bacterial disease, while the remaining one had pupated; it emerged as a moth, female, on August 22. This indicated a killing efficiency of 80 per cent in hand applications. Mr. Leiby at Terra Ceia secured similar results in cage work. Such explicit data could not have been established in field tests because many worms were already leaving the plants to pupate. The remedy was effective.

On August 8 a vigorous row 112 feet long was dusted by hand as would be done in field practice for potato beetles. Observed for over a month it showed no injury in comparison with an untreated row alongside. The remedy was safe.

Another row was treated very heavily, using several times more than could reasonably be needed,—the injury was slight and temporary, the row was soon as good as its check. The remedy was virtually fool-proof.

We also tested it at strength of one pound to four pounds lime; one pound to two pounds lime; one pound to one pound lime; and pure arsenate alone, all these being applied by hand. All of these greater strengths gave injury, more severe as the proportion of arsenate increased.

Similar tests with dusting machines showed that with these the greater strengths could be safely used, but were not necessary. A very careful farmer whose field was under observation tried arsenate alone successfully as a test on his own account, but the application was very light. That same farmer afterwards said that the arsenate remedy was so simple, so effective, and so practical that had he appreciated it at its full worth two weeks earlier he would be five thousand dollars better off—as it was he prevented much of the loss,—he considered the clover worm on soy beans as a solved problem. Other testimony to like effect could be quoted. The remedy was practicable, it was not prohibitive either in cost nor labor of application.

Inquiries after the outbreak was over proved that those who acted promptly on the advice were well pleased, though all appreciated that their applications would have been more effective if given earlier.

Very early-maturing varieties suffered much more than the ranker-growing later varieties. The difference was so pronounced as to be important, but we will not here discuss it further.

We did not find occasion to use a contact insecticide for the young larvæ, the arsenate was effective and safe for our purpose on this crop. We did not find it necessary to use any special effort or adjustment to reach the under side of the leaves, the larvæ soon ate all the way through on the young soy bean leaves. We did not find it necessary to make a painstaking application to all the leaves, if the uppermost expanded leaves were well treated the great majority of the worms were killed; hence the application could be made rapidly, and this was essential in such a wholesale outbreak as we were dealing with. We did not find it practicable to collect the larvæ in nets or sheets, for when a plant was suddenly and violently shaken certainly not over half of them fell. Collection of the moths by nets was wholly impracticable of economic results. They were only indifferently attracted to lights, we tried lanterns and bon-fires with negative results. Bait traps were also tried without important results.

Powdered arsenate of lead at rate of one pound to eight pounds of lime was effective, it was safe to the plant, and it is practicable in large areas of soy beans, more so of course when grown in rows,—it is not too costly, it pays a good profit on its use, especially if applied before the injury reaches its maximum. We admit that this calls for *promptness* with emphasis on every letter of the word.

Possible Danger in Using the Hay

This one point remains. Would it be dangerous to use the hay after such treatment as here advised? Important as this question seemed to the writer at first, it now holds little interest. Contemplated tests were not possible.

A plot dusted August 8 showed very little evidence of the dust on September 11, and as only one-ninth of this was arsenate the possible danger seems too remote for consideration. Normal harvest was still one or two months away by which time it is a moral certainty that all material danger would have been removed. As time went on the material disappeared from the plants, the question seemed to become trivial; farmers who at first questioned took the same view, they have ignored the fact that poison was ever applied, and we have had no recent questions and have not heard of any bad results.

MR. E. G. KELLY: I am deeply interested in this paper. In 1908, I went out to Kansas, and one of the first things I saw in an alfalfa field that had recently been cut was this green wriggly worm. I thought, from the numbers I saw on the ground after the alfalfa was removed, that a great deal of damage had been done or would be done by this species. Practically every year from that time up to the present, I have been in a lot of alfalfa fields, probably hundreds of them, and I have seen a lot of these worms; but this is the first record of devastation of which I have ever heard.

MR. W. E. BRITTON: Mr. Sherman is to be congratulated on the manner in which he handled the green clover worm on large areas of soy beans. I have had no experience in controlling a similar situation. An arsenical spray is without doubt the most effective and at the same time the least expensive treatment that could be practiced under such conditions, yet I would like to point out that occasionally there are cases where contact insecticides may be of value. Particularly in small bean patches in gardens, one hesitates to apply arsenate of lead to snap or string beans just before the crop is ready to harvest. On Lima beans or other beans to be shelled, of course there is no danger. These caterpillars are susceptible to the use of nicotine, and by spraying the under surface with nicotine solution, or even with common soap and water, many of them will be killed. A large proportion of them will drop to the ground when disturbed, and a forceful spray of water from the garden hose will dislodge many of them and injure them so that they will never find their way back to the foliage.

I saw a good many garden patches in Connecticut last year where the caterpillars did not eat holes entirely through the leaves; they ate small holes from the under side leaving the upper epidermis, and you could see those shining spots on the leaves for some distance away. This form of injury was most common on Lima beans, but was also observed on common varieties of snap and shell beans. We noticed that a great many of the caterpillars of varying sizes turned yellow and appeared sickly; but we did not attempt to ascertain the cause.

MR. ALVAH PETERSON: In New Jersey, this insect was very serious this year, on Lima beans particularly. It was necessary to coat the under surface of the leaf as well as the upper surface in order to secure control, because the young worms did not eat through the leaf. They fed entirely on the under surface.

MR. F. L. THOMAS: How does the insect pass the winter?

MR. FRANKLIN SHERMAN: It passes the winter as an adult moth hibernating under loose bark, sheds, buildings, and any kind of shelter it can find; it is often collected under loose bark on trees.

MR. GEORGE G. AINSLIE: That is one thing that we haven't been able to decide—how they spend the winter. Undoubtedly, moths are taken through the winter, but we have never been able to carry moths emerging late in the fall through to the next spring. Insects that went into the winter as pupæ and emerged during the winter were exposed and would remain through the latter part of the winter and late in the spring. Another thing—the moths that emerged late in the fall, we were totally unable to get eggs from. There are three or four generations a year, but those emerging in September never did mature the same season. Those emerging late in the winter produced eggs as soon as conditions were favorable in the spring.

MR. FRANKLIN SHERMAN: It is certainly well established that the adults do pass the winter. In what other stages they pass the winter I do not know. It has been suggested that the pupæ also pass the winter. That may be.

PRESIDENT W. C. O'KANE: The next paper is "The Life History of Some Kansas *Lachnosterna*," by W. P. Hayes.

THE LIFE HISTORIES OF SOME KANSAS LACHNOSTERNA[1]

By WILLIAM P. HAYES, *Assistant Entomologist, Kansas State Agricultural Experiment Station*

INTRODUCTION

The present study of the life histories of the more important species of Kansas *Lachnosterna* was begun in 1916. It is being carried out under the immediate direction of Mr. J. W. McColloch, to whom the writer's thanks are due for his kindly aid and criticism. The life history of one species, *Lachnosterna lanceolata* Say, a diurnal form has been previously published (Hayes, 1919). The data herein reported deal with observations on seven species of *Lachnosterna* found in the vicinity of Manhattan, Kans., five of which have been discussed by Davis (1916) in his notable report on the life-cycle of 18 different species. The two species considered in this paper and not dealt with by him are *L. rubiginosa* and *L. submucida*. The former, in point of numbers, ranks second among the night-flying species in the vicinity of Manhattan, and *L. submucida* ranks sixteenth.

In rearing, the eggs were obtained in small, soil cages and transferred to moist soil in salve boxes in much the same manner as described by Davis (1915, pp. 137–138). On hatching, the grubs were reared to maturity in individual salve boxes and kept in the insect cave described by McColloch (1917). Daily observations could thus be made to

[1] Contribution No. 39 from the Entomological Laboratory, Kansas State Agricultural College. This paper embodies the results of some of the investigations undertaken by the author in the prosecution of project No. 100 of the Kansas Agricultural Experiment Station.

determine the length of the prepupal stage, heretofore unrecorded, and the exact dates of pupation and transformation to the imago.

In general, it may be said that the results corroborate those of Davis in that a decided variation of length of the larval stage occurs in most of the species observed. Thus, some species have in the latitude of Kansas either a two or three-year life-cycle.

Species Concerned and Relative Abundance

The seven species under consideration are *L. crassissima* Blanch. (fig. 1a), *L. rubiginosa* Lec. (fig. 2), *L. futilis* Lec. (*gibbosa* Horn), *L. rugosa* Mels., *L. implicata* Horn, *L. vehemens* Horn, and *L. submucida* Lec., named in the order of their abundance at Manhattan.[1]

Fig. 11.—*Lachnosterna crassimana* Blanch; *A*, adult; *B*, egg; *C*, larva; antenna of female and male.

Sanders and Fracker (1916, p. 256) have shown that a remarkable variation in the distribution of the different species of this genus may occur within a distance of thirty or forty miles. The data herein given may thus be only applicable to the vicinity of Manhattan, Kans.

L. crassissima.—This species is the predominating one of the night-flyers in the area under consideration. During the past four seasons 15,655 specimens, or 32 per cent of the total collections of all species (47,494 specimens) were collected at lights, on food plants and in the soil. Over 99 per cent of these beetles have been taken at lights, although regular collections have been made on some forty species of plants.

L. rubiginosa.—Ranking second among the nocturnal *Lachnosterna* of this locality, this

[1] *L. lanceolata* is the most prevalent species in this vicinity. It is excluded from the above list and following discussion because of its diurnal habits, although its collection numbers are included in the total collections and percentages based thereon.

species comprises 13 per cent of the collections with a total of 6,191 specimens taken. The collections show that *L. rubiginosa* is more abundant on food plants than at lights, where 69 per cent of all taken were found.

L. futilis (*gibbosa*).—A total of 5,680 specimens of *L. futilis*, or 11 per cent of the total collections have been made in the last four seasons, giving to this species third place in point of numbers. In all, 4,521

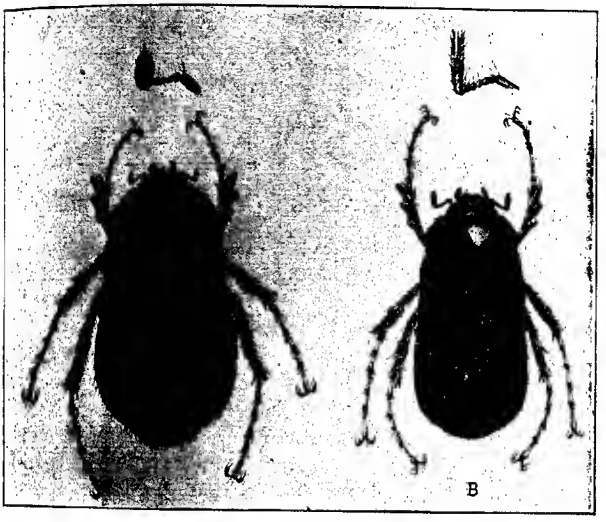

Fig. 12.—*Lachnosterna rubiginosa* Lec.; *A*, male; *B*, female.

beetles, or 79 per cent were collected at lights, 1,150 on food plants, and five in the soil.

L. rugosa.—This species stands fourth in abundance with a total of 2,379 beetles, of which 79 per cent were taken at lights.

L. implicata.—The collections of *L. implicata* amount to 827 individuals which places the species fifth in importance. The majority, or 68 per cent, were taken on food plants.

L. vehemens.—Two other species of Kansas *Lachnosterna* (*L. hirticula* and *L. bipartita*) not considered in this paper stand, in point of numbers, ahead of *L. vehemens* which ranks eighth with a total of 437 specimens collected. Of these 429 were taken at lights.

L. submucida.—Among the 23 species of *Lachnosterna* collected in the area under consideration, *L. submucida* ranks sixteenth. It is represented by only 18 specimens, but one of which was taken on food

plants. The following biological observations on the species were made possible by the collection of a number of eggs in 1917 which, when reared to maturity, proved to be those of *L. submucida*.

Table I gives a comparison of the numbers collected during the past four seasons. An attempt was made to make the collections uniform by collecting nightly from the opening to the close of the season of flight. During the 1916 season, tree and food plant collections were neglected for light collections and in 1919 the reverse was true, light collections being neglected for food plants, so on the whole, the collecting is thought to be somewhat uniform for the four years.

TABLE I.—SUMMARY OF TOTAL COLLECTIONS

Species	1916 Brood C	1917 Brood A	1918 Brood B	1919 Brood C	Total
L. crassissima	3,412	10,244	856	1,143	15,655
L. rubiginosa	104	5,176	802	109	6,191
L. futilis	1,192	3,217	381	890	5,680
L. rugosa	571	1,301	188	319	2,379
L. implicata	395	214	131	87	827
L. vehemens	77	341	11	8	437
L. submucida	11	4	1	2	18
					31,187

LIFE HISTORY

Adults

Period of Flight.—The flight season begins as early as April 18 in the vicinity of Manhattan, and with the species concerned may last until the middle of August. The maximum period of flight occurs in May and June, except in the case of *L. submucida*, which is a late flying species that pupates in June and July and flies soon after becoming adult. It does not pass the winter in the adult stage as do the other species. In general, it can be said that *L. futilis*, *L. rubiginosa*, and *L. vehemens* appear first with *L. crassissima* and *L. rugosa* soon following. Specimens of *L. implicata* have not been taken before May 6, and *L. submucida* does not fly until July. Table II shows the earliest and latest dates on which the species have been found either at lights or food plants.

TABLE II.—PERIOD OF FLIGHT

Species	Earliest collection	Last collection	Period of flight. Days
L. futilis	April 18	July 21	94
L. rubiginosa	April 18	Aug. 8	112
L. vehemens	April 18	June 23	66
L. crassissima	April 22	Aug. 17	117
L. rugosa	April 23	July 12	80
L. implicata	May 6	July 21	76
L. submucida	July 7	Aug. 17	41

Proportion of Sexes.—The sexes of *Lachnosterna* are commonly known to differ somewhat in their habits of flight. It is generally stated that males are more abundant at lights and females more numerous on food plants. Males of the seven species under consideration with the exception of *L. implicata*, have been found more plentiful at lights. In the case of *L. implicata*, it is to be noted that males are proportionately rare and not found to any extent in any situation. Table III shows the proportions of sexes of the seven species collected during the 1917–1918 seasons, and of all reared individuals.

In sex ratios, the collections on food plants show different relations in the different species. More males were found than females of *L. crassissima*, *L. futilis*, *L. rugosa* and *L. vehemens*, while *L. rubiginosa* and *L. implicata* females were the more numerous.

Two noticeable points are brought out by the table. It can be seen that *L. crassissima* is represented on food plants by less than one per cent of the total collections, while 71 per cent of *L. rubiginosa* beetles were collected on food plants. Although the most abundant, the absence of *L. crassissima* on food plants indicates a preference for some food which has not yet been found. Schwarz (1891, p. 241) states that adults of *L. crassissima* probably feed on grass or low herbage.

Eggs

The eggs (fig. 11, b) are white in color and when freshly laid are oval in shape, varying slightly in size with the different species. The eggs of *L. futilis* are somewhat smaller than those of the other six species, with an average measurement of 1.7 mm. in length and 1.2 mm. in width, while *L. rugosa* eggs, when freshly laid, are about 2.6 mm. long and 1.8 mm. wide. An enlargement, accompanied by a slight increase in weight, occurs as development proceeds, causing the eggs to assume a more globular appearance. Daily measurements of the eggs show a gradual increase in size during the earlier periods of development until both dimensions have increased about .5 to .7 mm.

Table IV gives a summary of the length of the egg stage of the seven species during four seasons under observation.

The *L. submucida* eggs were collected in a field soon after laying and represent a somewhat longer period of development than is given in the table. The maximum length of egg stage varies from 20 to 38 days with the various species, and the minimum ranges from 9 to 19 days. General averages of the seven species range from 14 plus in *L. submucida* to 20.8 days in *L. futilis*.

The preoviposition period was determined in the case of *L. crassissima* at about 12 days. The number of eggs laid by an individual female is reported by Davis (1916, p. 263) as from 50 to 100. In no

TABLE III.—SUMMARY OF PROPORTION OF SEXES

	L. crassissima			L. rubiginosa			L. futilis			L. rugosa			L. implicata			L. vehemens			L. submucida		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
Collected at Lights	2,510	9,592	12,102	462	1,265	1,727	326	3,028	3,354	414	920	1,334	51	3	54	52	300	352	0	4	4
Collected on Food Plants	41	53	94	2,217	2,096	4,313	488	643	1,131	192	264	456	353	28	376	1	7	8	1	0	1
Collected in Soil	20	29	49	18	29	47	3	0	3	6	13	19	2	0	2	0	0	0	2	1	3
Reared from Collected Grubs	51	49	100	29	19	48				24	29	53	14	0	14	0	0	0	1	1	2
Reared from Egg	40	38	78	14	15	29	7	9	16	9	12	21	19	3	22	1	0	1	5	8	13

TABLE IV.—LENGTH OF EGG STAGE

Species	1916				1917				1918				1919				Total			
	No. of eggs	Max. days	Min. days	Aver. days	No. of eggs	Max. days	Min. days	Aver. days	No. of eggs	Max. days	Min. days	Aver. days	No. of eggs	Max. days	Min. days	Aver. days	No. of eggs	Max. days	Min. days	Aver. days
L. crassissima	466	26	9	18.2	126	21	11	13.9	77	19	9	14.1	159	20	13	15.6	828	26	9	15.4
L. rubiginosa	42	18	14	16.3	269	21	9	12.3	110	24	11	17.	13	21	12	17.9	434	24	9	15.8
L. rugosa	42	24	9	15.6	60	29	9	14.9	2	18	11	14.5	73	22	14	18.6	177	29	9	15.9
L. implicata	28	31	11	24.5	16	21	13	17.2	86	20	11	17.6	65	20	13	16.3	195	31	11	18.9
L. futilis	110	31	16	23.	145	38	18	24.5	33	19	11	15.4	610	30	14	20.1	888	38	11	20.8
L. vehemens					2	28	19	23.5									2	28	19	23.5
L. submucida					83	20+	13+	14.+									83	20+	13+	14.+

instance, in the present study were more than 46 eggs laid by any female in laboratory cages. They are deposited singly in the soil and surrounded by a small earthern ball which is held in shape by a secretion from the female. The earliest date on which eggs were found in the cages was May 22. In most instances, the first species to oviposit has been *L. futilis* and it has been observed to continue egg laying until July 12.

During three seasons of the four under discussion, eggs of *L. futilis* have been the first to hatch at dates ranging from June 18 to June 27. The exception was in 1918 when eggs of *L. crassissima* were the first to hatch at a somewhat earlier date, June 10.

Larvæ

The larvæ, or grubs (fig. 11, c), of this genus are adequately described by Davis (1916, p. 265) as "white or cream white, the dark contents of the intestinal tract being plainly visible through the skin of the last few abdominal segments. The head is light tan in color, smooth and shiny and the body is covered with reddish brown hairs, those on the dorsum of the folds or ridges being short and more thickly placed. The ventral surface of the anal segment, which shows the most prominent character, bears a triangular patch of brownish hairs which are hooked at the tip, with an intermixing, especially at the borders of the patch, of fine, long hairs, and with a median longitudinal double row of coarse hairs or spines inclined more or less inwardly. These rows may be straight and parallel or more or less curved; short or long; and the spines in the rows may be sparsely or closely placed according to species. The anal slit is in the form of an obtuse angle." The young larva, when freshly hatched, is pure white, but the head soon assumes the characteristic brownish tinge.

Davis (1916, p. 262) and others have shown that latitude bears an important influence on the life-cycle of species of this genus. The farther northward a species is found the longer is the life-cycle. Smyth (1916, p. 47) in Porto Rico reared *Lachnosterna* from egg to adult in 324 days—less than one year—while Davis states that in northern Wisconsin four years are required to complete development. Davis has likewise shown, and the present data confirm his observations, that a difference of one season may occur in the time of development of grubs of the same species. This difference is due to variation in the length of the larval stage. In Table V, the larval periods from time of hatching to the attainment of the prepupal condition of some 230 individuals are considered.

The species under consideration all pupate in the fall and pass the winter as adults, except *L. submucida*, which transforms in the spring.

TABLE V.—LENGTH OF LARVAL STAGE FROM HATCHING TO PREPUPA

Species	Two-year grubs				Three-year grubs				Totals			
	No. of grubs	Max. days	Min. days	Aver. days	No. of grubs	Max. days	Min. days	Aver. days	No. of grubs	Max. days	Min. days	Aver. days
L. crassissima	71	459	406	423.4	35	823	732	752.8	106	823	406	598.4
L. rubiginosa	4	497	402	454.5	43	798	742	770.8	47	798	402	686.1
L. futilis	18	424	389	408.2	1	773	773	773.	19	773	389	488.1
L. rugosa	5	412	399	406.2	17	778	750	758.8	22	778	399	582.5
L. implicata	21	429	393	404.3	1	743	743	743.	22	743	393	421.9
L. vehemens					1	770	770	770.	1	770	770	770.
L. submucida	13	687	658	668.6					13	887	658	668.6

TABLE VI.—LENGTH OF THE PREPUPAL STAGE

Species	1916 Generation				1917 Generation				1918 Generation				From collected grubs				Totals			
	No. of pre-pupæ	Max. days	Min. days	Aver. days	No. of pre-pupæ	Max. days	Min. days	Aver. days	No. of pre-pupæ	Max. days	Min. days	Aver. days	No. of pre-pupæ	Max. days	Min. days	Aver. days	No. of pre-pupæ	Max. days	Min. days	Aver. days
L. crassissima	65	19	7	12.1	28	10	3	7.8					76	12	3	7.3	169	19	3	9.
L. rubiginosa	5	9	4	7.2	32	11	3	7.1					28	11	3	5.7	65	11	3	6.6
L. futilis	15	9	5	7.1	2	8	7	7.5									17	9	5	7.3
L. rugosa	5	9	3	6.2	16	30	6	12.3					46	15	4	8.3	67	30	3	8.9
L. implicata	20	11	3	7.8					2	11	6	8.5	10	10	4	7.	32	11	3	7.7
L. vehemens					1	7	7	7									1	7	7	7
L. submucida					13	11	5	7.9					1	6	6	6.	14	11	5	6.9

This difference in time of pupation produces a longer larval period in such species than in the normal forms. Perusal of Table V shows that the maximum length of the period in two-year grubs was 497 days (*L. rubiginosa*) and the minimum period 393 days (*L. implicata*) with averages for the different species ranging from 404 to 454 days. In the case of *L. submucida* (all two-year grubs), 687 days was the maximum and 658 days the minimum period of development with an average of 668.6 days, giving differences between the averages ranging from 214 to 264 days. In other words, from seven to eight months longer are necessary for larval development in two-year species of this type.

The three-year grubs pass through two winters and pupate the second season. A maximum period of 823 days was required for development in the case of *L. crassissima*, and a minimum of 732 days with averages for the different species varying from 743 to 773 days. A difference of 339 days is noted between the minimum larval stages of the two and three-year grubs.

From the data at hand, there appears to be an alternation in the appearance of the two and three-year grubs; *e. g.*, among the generation of *L. crassissima* hatching in 1916, 85 grubs were reared. Of these, 71 were two-year grubs and 5 were three-year grubs. The generation hatching in 1917 produced only three-year grubs. This difference in the case of *L. rubiginosa* was not so marked. In the case of *L. rugosa*, only two-year grubs were raised from the 1916 brood and the 1917 brood produced only three-year grubs. Field collections made during the time of this study indicate a close correspondence to the broods A, B, and C, described by Davis (1918, p. 16) with 1917 as the time of appearance of brood A; 1918 brood B, and 1919 brood C. The alternation in the appearance of the two and three-year grubs in rearing cages, if true in nature, may be a contributing factor to the explanation of variations in size of the minor broods B and C, as for example, brood C is generally considered to be smaller than B. The 1916 brood C at Manhattan was on the whole much larger than the 1918 brood B, and may be due to the variation in time of appearance of the greater number of two and three-year grubs.

The Prepupæ

The prepupal stage begins near the close of larval development when the grub sheds its meconium and assumes a quiescent stage preparatory to pupation. This stage was found to vary from 3 to 30 days with averages for the different species varying from 6.9 to 9 days. The maximum, minimum and average prepupal periods for the seven species are shown in Table VI.

TABLE VII.—SUMMARY OF LENGTH OF LARVAL AND PREPUPAL STAGES COMBINED

Species	Maximum days		Minimum days		Average days	
	Two-year grubs	Three-year grubs	Two-year grubs	Three-year grubs	Two-year grubs	Three-year grubs
L. crassisaima	478	842	409	735	432.4	761.8
L. rubiginosa	508	809	405	745	461.1	777.4
L. futilis	433	782	394	778	415.5	780.3
L. rugosa	442	808	402	753	415.1	767.7
L. implicata	440	754	396	746	412.	750.7
L. vehemens		777		777		777.
L. submucida	698		663		675.5	

TABLE VIII.—LENGTH OF PUPAL STAGE

Species	1916 Generation				1917 Generation				1918 Generation				From collected grubs				Totals			
	No. of pupæ	Max. days	Min. days	Aver. days	No. of pupæ	Max. days	Min. days	Aver. days	No. of pupæ	Max. days	Min. days	Aver. days	No. of pupæ	Max. days	Min. days	Aver. days	No. of pupæ	Max. days	Min. days	Aver. days
L. crassisaima	56	58	16	37.4	22	27	25	25.8					100	49	19	28.3	178	58	16	30.5
L. rubiginosa	3	30	24	27.6	26	35	25	27.7					48	35	22	28.	77	35	22	27.7
L. rugosa	5	50	28	32.2	16	34	26	29.7					53	36	25	29.1	74	50	25	30.3
L. implicata	20	28	20	24.4					2	23	13	18	14	28	21	24.4	36	28	13	22.2
L. futilis	14	33	27	28.4	2	24	23	23.5									16	33	23	25.9
L. vehemens					1	23	23	23.									1	23	23	23.
L. submucida					13	29	19	24.8					2	19	19	19.	15	29	19	21.9

A combination of the maximum, minimum, and average periods of the larval and prepupal stages representing the complete larval stage is shown in Table VII.

Among the two-year grubs, the combined maximum of the two stages was greatest in the case of *L. rubiginosa* with a period of 508 days, excepting *L. submucida* which required 698 days, and the minimum was 394 days. The minimum for *L. submucida* was 663 days with an average of 675.5 days. The averages of the other two-year species vary from 411.7 to 461.1 days.

The three-year grubs averaged from 761.8 to 780.3 days, with a maximum of 842 days and a minimum of 735 days in *L. crassissima*.

Ecdysis occurs twice before the pupal molt. As observed, the two molts previous to pupation in the two-year grubs occur, as a rule, during the same season that the egg is hatched, but rarely the second molt may be delayed until the following summer. Among the three-year grubs, one molt occurs during the season the egg is hatched, and the second occurs the following year. To illustrate: two-year grubs hatching in 1916 molted twice in 1916 as a general rule, but in a few instances the second molt was delayed until 1917. The three-year species hatching in 1917 molted once during the summer of 1917 and once in 1918. All of the grubs molt at pupation, and generally the pupa lies within the cast-off exuvium.

Pupæ

Besides the data obtained on a large number of reared individuals, the records on the length of the pupal stage are augmented by the addition of records of a somewhat larger number of specimens reared from grubs collected in nature. In general, no striking difference is to be noted between the periods of development of those reared and those collected, except in the case of specimens of *L. crassissima* reared from the 1916 brood in which the general average of 37.4 days for 56 pupæ was much higher than averages of other seasons or species.

Table VIII shows a comparison of the time of development in the seven species reared since 1916.

From the table, it can be noticed that the longest period of development occurred in the 1916 brood of *L. crassissima* where a single individual required 58 days to mature and in the same brood a minimum period of 16 days was required. The averages of the different species vary from 21.9 days in the case of *L. submucida* to 30.5 days in *L. crassissima*.

Length of Life Cycle

L. crassissima.—Of 106 individuals reared through the larval stage, 71 were the so-called two-year grubs and 35 three-year forms. The

egg period was found to average 15.4 days. The two-year larval and prepupal stages averaged 432.4 days and in the three-year larvæ 761.8 days. The pupal stage of 106 individuals averaged 30.5 days. Combining the averages of the egg, complete larval, and pupal stages, an average period is obtained in this species of 478.3 days in the two-year forms, and an average of 807.7 days for the three-year individuals was required from egg to adult.

L. rubiginosa.—Forty-seven beetles of this species were reared from egg to adult. Four of them were two-year and 43 three-year grubs. The average egg period was 15.8 days. The complete larval stage averaged 432.4 days, and 761.8 days in the two and three-year beetles, respectively. The average pupal period of 77 pupæ was 27.7 days. Combining these figures, averages are obtained of 475.9 days for the two-year and 805.3 days for the three-year individuals.

L. futilis.—One three-year grub and 18 two-year grubs of this species were reared. The average egg period was 20.8 days, the combined larval stage averaged 415.5 days for the two-year, and 780.3 days for the three-year grubs, and the pupal average was 25.9 days. Averages of 462.2 days and 827 days are obtained for the different periods of growth by adding the above figures.

L. rugosa.—The egg stage of this species averaged 15.9 days, the two complete larval periods 415.1 and 767.7 days, and the pupal average 30.3 days. For five two-year beetles an average of 461.3 days and for 17 three-year adults an average of 813.9 days were required to complete development.

L. implicata.—The combined averages of this species show a two-year life cycle of 452.8 days and a three-year cycle of 791.8 days. The averages of the stages were computed as follows: egg 18.9 days, larva 411.7 and 750.7 days, and pupa 22.2 days.

L. vehemens.—One specimen reared from egg to adult required 845 days to mature.

L. submucida.—This species was reared in two years and grubs of the same brood are now passing the winter indicating also a three-year cycle. The egg stage averaged something over 14 days, the complete larval stage 675.5 days and the pupal 21.9, giving a two-year cycle of slightly over 711 days as the average of 13 individuals.

Food Plants

Adult.—Regular nightly collections on certain designated food plants have been made throughout the flight seasons of the adult beetles during the past four seasons to determine, if possible, the preferred food of the adults. Table IX shows the different food plants upon which the various species were collected.

TABLE IX.—LIST OF FOOD PLANTS

L. rugosa	*L. futilis*	*L. rubiginosa*	*L. crassissima*	*L. implicata*	*L. vehemens*	*L. submucida*
Willow	Hackberry	Hawthorn	Strawberry	Willow	Hawthorn	Bluestem grass
Locust	Hawthorn	Horse-chestnut	Elm	Apple	Horse-chestnut	
Hawthorn	Horse-chestnut	Locust	Oak	Silver poplar	Hackberry	
Hackberry	Linden	Hackberry	Catalpa	Cottonwood	Plum	
Silver poplar	Elm	Oak	Apple	Locust	Ash	
Birch	Locust	Elm	Linden	Hackberry		
Box elder	Birch	Coffee tree	Locust	Linden		
Oak	Cherry	Linden	Birch	Elm		
Cottonwood	Norway maple	Birch	Hackberry	Hawthorn		
Coffee tree	Spirea	Norway maple	Dock	Redbud		
Horse-chestnut	Coffee tree	Redbud	Hawthorn	Horse-chestnut		
Cherry	Oak	Tulip tree	Box elder	Cherry		
Plum	Box elder	Box elder	Horse-chestnut	Dock		
Norway maple	Ash	Ash	Ash	Privet		
Peach	Plum	Apricot	Cottonwood			
Persimmon	Rose	Cherry	Œnothera			
Pear	Mulberry	Peach	Amorpha canescens			
Elm	Silver poplar	Persimmon	Specularia perfoliata			
Redbud	Sumac	Strawberry	Pepper grass			
Strawberry	Catalpa	Silver poplar	Sumac			
Ash	Apple	Tamarack	Ironweed			
Spirea	Privet	Privet	Tamarack			
Apple	Tamarack	Catalpa				
Linden	Chinese sand-plum	Hickory				
Catalpa	Tulip tree					
Privet	Raspberry					
Dock	Peach					
Chinese sand-plum	Cottonwood					
Tamarack	Siberian pea					
Radish	Blue grass					
Sunflower	Dock					
Pepper grass	Orchard grass					
Thistle	Wild rose					
Raspberry						
Petunia						

GRUB.—The grubs were reared in the life history cages throughout their period of growth on grains of wheat which were replaced weekly in the warmer months and entirely removed during the winter. The frequent change of food was necessary because of the development of fungi and as a result, until the grain germinated, no roots were available. The larger grubs would often consume the grain before germination.

The records in this study show the following food plant locations of the different species, based on the rearing to adults of grubs collected in the fields.

L. crassissima.—Three situations have yielded the largest number of this species. Thirty-one per cent of all reared have been taken in corn fields, 25 per cent in bluegrass sod, and 17 per cent in garden tracts where a variety of food was available. This species has also been reared from grubs collected in pastures, oat fields, strawberry beds, crab grass roots, a rhubarb bed, sunflower roots and bindweed roots.

L. futilis.—No grubs of this species have been reared from any of the collecting regions around Manhattan, despite the prevalence of the adults.

L. rubiginosa.—Twenty-nine per cent of the grubs of this species which matured were from corn, 21 per cent from bluegrass, and 17 per cent from garden tracts. Other places where the grubs were found consist of pastures, oat fields, strawberry beds, rhubarb beds, sunflower roots and potato patches.

L. rugosa.—The most striking food preference of any of the grubs was exhibited by this species where 41 per cent of all reared were taken from land devoted to gardening. Twenty per cent were taken in corn ground, and five per cent in bluegrass sod. Sorghum, wheat, and oat fields, strawberry and rhubarb beds, sunflower roots, potato patches, petunia roots and ironweed roots have yielded grubs of this species.

L. implicata.—This species has been found in corn, wheat and oat fields.

L. submucida.—This species has been found only at the roots of bluestem pasture grasses. The eggs from which this species were reared were found at the roots of ironweed which may be a preferred food plant of the grubs.

L. vehemens.—No data concerning the food preference of *L. vehemens* grubs are at hand.

NATURAL ENEMIES

Davis (1919) has recently published a comprehensive monograph of the natural enemies of this genus and little need be said here concerning them, except to enumerate the enemies encountered during these studies.

Enemies of the Grubs.—In the vicinity of Manhattan, three of the four species of *Tiphia* commonly parasitic on grubs have been found. The most important species is *T. punctata* Rob. The others, *T. transversa* Say and *T. inornata* occur rarely and *T. vulgaris* although recorded by Davis as occurring in Kansas has not been taken during this study. Among the banded digger-wasps, *Ellis 5-cincta* Fabr., and *E. interrupta* Say are rather common in this region. The Tachinid *Microphthalma disjuncta* Wied. (determined by Aldrich) has also been reared.

Hairworms of the family *Mermethidæ* have been frequently reared from grubs. Nematodes, probably *Diplogaster ærivora* Cobb, killed many grubs in rearing cages during the summer of 1919. They were also especially abundant in a collection of grubs, those of which survived proved to be *L. lanceolata*. Attempts were made without success to inoculate grubs from cultures of the nematodes. Mites, fungi and bacterial diseases have likewise proved obnoxious in rearing cages. Asilid larvæ have frequently been observed attacking grubs. So far, none of these have been reared to maturity. Toads, birds, and moles have been noted feeding on grubs.

Enemies of the Adults.—Two dipterous parasites, *Pyrgota valida* Harris, and *Cryptomeigenia theutis* Walk. are apparently the most active enemies of May beetles in this region. In this work, *C. theutis* has been reared from *L. futilis, L. implicata, L. rugosa, L. crassissima,* and *L. crenulata;* and *P. valida* from *L. crassissima, L. implicata, L. rugosa, L. rubiginosa,* and *L. bipartita.* Another enemy, *Eutrixa exile* Coq., was reared from *L. rubiginosa.* Miscellaneous enemies, such as mites, toads, cats, birds and spiders have been noted. Two carabid beetles, *Scarites substriatus* Hald., and *Pasimachus* probably *punctulatus* Hald., were observed attacking adults. In the case of the former, two adults were noted chasing and biting at the legs of June bugs under an electric light.

Summary

The life histories of seven species of *Lachnosterna* found in the vicinity of Manhattan, Kansas, are herein considered. Five of these, *L. crassissima, L. rubiginosa, L. futilis, L. rugosa,* and *L. implicata,* in the order named are the most abundant in this locality. The other two, *L. vehemens* and *L. submucida* ranked eighth and sixteenth, respectively. Their flight periods begin about April 18 and may last as in the case of *L. submucida* until Aug. 17.

The egg stages were found to average from slightly over 14 days to 29.8 days. The larval period varied, two and three-year life cycles occurring for the five important species. Only a three-year cycle was observed in the case of *L. vehemens* and grubs now living in rearing

cages indicate a three-year cycle for *L. submucida* besides the two-year cycle discussed.

The prepupal stage averaged from 6.6 days to 9 days for the different species, and the mean pupal stage varied from 21.9 days to 30.5 days.

The averages of the two and three-year life cycles for the different species were 478.3 days and 807.7 days for *L. crassissima*, 475.9 days and 805.3 days for *L. rubiginosa*, 462 days and 827 days for *L. futilis*, 461.3 and 813.9 days for *L. rugosa*, 411.7 and 750.7 days for *L. implicata*, and 845 days for *L. vehemens*. *L. submucida* pupates in the spring instead of the fall, and thus a two-year cycle is produced which nearly equals the period of development of the three-year individuals. The average period for the species was slightly over 711 days.

A list of food plants of the adults, and situations apparently preferable to the grubs are given as is also a list of natural enemies found or reared during this study.

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THE CHINCH BUG IN MONTANA

By J. R. PARKER, *Bozeman, Montana*

What is believed to be the first record of the occurrence of the chinch bug (*Blissus leucopterus* Say) in Montana was obtained in 1911 when on May 23 a number of fourth instar chinch bugs were sent in from Glasgow, which is in the Missouri River Valley in the northeastern part of the state. Our observations concerning the chinch bug have been very interesting to us, not only because they concerned an insect

of great economic importance hitherto not known to occur in Montana, but because its life history differed so strikingly from that reported by workers in other states.

Notes on Seasonal History

The most surprising feature about the chinch bug in Montana concerns its seasonal history. According to Webster[1] and other workers, the chinch bug hibernates only as an adult and even in the more southern states, where there are two broods, the majority of the first generation do not reach maturity until July. Finding fourth instar nymphs as early as May 23, therefore, immediately led us to believe that the insects might have hibernated as nymphs rather than as adults. The farmer who sent in the chinch bugs stated that he first noticed them about April 15, when they appeared to be the same size as those sent to the Station on May 23, *i. e.*, fourth instar nymphs. Nymphs placed upon oats in the insectary at Bozeman transformed to adults on June 12. Pairing was observed in the rearing cage throughout the month of July and August, but no eggs were seen until August 20. On September 1 about one-third of the adults were still alive, but as yet no young had been seen. On October 5 all the adults were dead, but in the cage were a number of dead and a few living chinch bugs in the first and second instars. None of these survived the winter.

On June 26–30 of the same year, the writer visited the Glasgow district and found chinch bugs very abundant in prairie grass and in much smaller numbers in cultivated crops. The nymphs by this time had all transformed to adults, many of which were pairing.

The same district was visited again on May 13, 1913. It had been under water for several weeks, during the spring floods of 1912, which may account for the scarcity of chinch bugs that prevailed. Only six were found in a day's search over the territory where they had occurred so abundantly in 1911. Four of these were in the fourth instar and two were in the third. The season was backward and on that date the buds on the cottonwood trees had not unfolded.

On June 4, 1914, the same vicinity was examined, but a two days' search netted only two chinch bugs, both adults.

On November 6, 1915, an entire day was spent searching for chinch bugs at Glasgow, but not one could be found. During the summer of 1919 this territory was searched on two different occasions but no chinch bugs were discovered.

Indications of Hibernation of Nymphal Stage

Kelly and Parks[2] state that in Kansas and Missouri in 1909 the

[1] Bureau of Entomology—Bulletin 69, page 10.

[2] Bureau of Entomology—Bulletin 95, Part III, page 28.

first newly transformed adults were secured on July 5. Headlee and McColloch[1] state that at Manhattan, Kansas, in 1912, the first fourth instar nymphs were obtained on June 4 and were at their maximum abundance on June 30; that the first newly transformed adults were taken on June 14 and were at their maximum on July 10.

In Montana fourth instar nymphs were at their maximum abundance in 1911 as early as May 23, and prohably on April 15. Newly transformed adults were ahundant on June 12, and in 1914 several were secured on June 4. It does not seem possihle that the seasonal history of the chinch hug in Montana could be a month earlier than in Kansas and Missouri, which are 10 degrees further south and the only reasonahle explanation of the appearance of fourth instar nymphs in April and May is to assume that they hibernate in that stage.

This assumption is further strengthened hy Hopkin's law of latitude, longitude and altitude[2] which states that the variation on the date of a periodical event in the seasonal activities of a plant or animal is at the average rate of four days for one degree of latitude, 5 degrees of longitude, or 400 feet of altitude. Glasgow is 10 degrees north and 10 degrees west of Manhattan, Kansas, and is ahout 800 feet higher. Applying Hopkin's law to the statement of Headlee and McColloch, that fourth instar nymphs are at their maximum abundance on June 30 at Manhattan, Kansas, we would not expect to find them in abundance at Glasgow until 38 days later, or July 8. Instead of this we find them in abundance on May 23 and reported in ahundance as early as April 15. It therefore seems impossible that these nymphs could have developed from eggs laid that same season.

Perhaps no definite statement should be made until we find the chinch bug in its winter quarters, but the above data, together with the fact that adults, which emerged in the insectary on June 12, produced progeny which failed to mature that season, indicates that in Montana the chinch bug changes its usual habit and hihernates as a well advanced nymph.

Host Plants

In the Glasgow district chinch hugs were first noticed in a field of oats which was said to be swarming with nymphs in May and the owner was very positive in his statement that many of the young plants had heen killed. Chinch bugs were also found in June upon wheat and corn, hut as far as could he learned no serious injury occurred.

Chinch hugs occurred most ahundantly upon the native grasses.

[1] Kansas Agricultural Experiment Station, Bulletin 191, page 303.

[2] Jour. of Econ. Ent., Vol. 10, No. 1, page 160.

In June, 1911, the writer found that nearly every clump of hunch grass upon the open prairie harhored from one to twelve adults and during thc first week in May unbroken sod land in the vicinity was said to have swarmed with nymphs.

Forms Found

Both long and short winged forms were found in ahout equal numbers.

Distribution

The area so heavily infested by the chinch hug in 1911 lies south of Glasgow between the Milk River and the Missouri River and covers at least four square miles. During the same year an area of five or six square miles lying north of the Milk River in the vicinity of Glasgow was examined in many places, but not a chinch hug could be found. At Hinsdalc, 30 miles west of Glasgow, several chinch bugs were found in the first two whcat fields examined, hut no more could be found anywhere during a five hour search. It therefore seems probable that while the most severe infestation in 1911 was in the district south of Glasgow, the insects also occurred scatteringly over a much larger territory. It has not heen ahundant at Glasgow since 1911.

On July 2, 1915, an adult chinch bug was taken by H. L. Seamans at Brady, which is 240 miles west of Glasgow and only about 40 miles from the continental divide. The elevation at Glasgow is 2,087 feet and at Brady 3,800 feet.

Source of Infestation

The finding of the chinch bug in Montana is not surprising, for it has long been threatening the southern and eastern borders of the state. In 1905, Wehster[1] mapped it as occurring over all the eastern, southern and central states, and as far north as Manitoba. The western boundary of the infested area passed through central Colorado, out into the southeastern corner of Wyoming, passed diagonally across western South Dakota and cut North Dakota almost in half. It is probable that from this infested area the chinch bug has slowly worked its way up the valley of the Missouri River.

Mr. E. D. Ball: Have you had these chinch bugs examined hy specialists?

Mr. J. R. Parker: They were examined by Mr. Van Duzee.

Mr. E. D. Ball: I collected a species of chinch bug in the northern part of the state of Colorado, beyond the prescnt range of the chinch bug and they were determined hy Professor Montandon, the world's specialist on chinch bugs, as a different species from that in the south.

[1] Bureau of Entomology Bulletin, 69, page 11.

MR. J. R. PARKER: I might say we found both long- and short-winged forms.

MR. E. D. BALL: That sounds rather suspicious.

MR. J. R. PARKER: We found these at an elevation of 2,087 feet.

DR. L. O. HOWARD: When did you send your specimens to Montandon? Before the war?

MR. E. D. BALL: Ten years before the war.

MR. COTNAM: Our main method of control in Kansas is based upon the hibernation of the bug. Since 1910 we have examined hundreds of grasses and found that they go into hibernation, but we have never found them after the middle of December. We do find that in Kansas we have a variation of the hibernation and a variation in the appearance. Sometimes the bugs leave hibernation in March and are found early in the spring. In other years, the bugs do not leave hibernation until May.

PRESIDENT W. C. O'KANE: The next paper is by Mr. Haseman.

THE HESSIAN FLY AND FACTORS INFLUENCING ITS RELATION TO WHEAT PLANTS

By LEONARD HASEMAN

(Withdrawn for publication elsewhere.)

Adjournment.

Scientific Notes

A Predaceous Enemy of Bean Weevils. While watching a bean weevil (*Bruchus quadrimaculatus* Fab., ovipositing, in June, 1919, the writer became convinced that there was something abnormal about its actions. After the weevil had deposited each of four eggs, it stroked its elytra with its hind legs; rapidly whipped its antennae back and forth; tried to bite its fore tibiae; extended its head as far as possible beneath its body; tried to roll over and then extended its wings as if to fly; closed them up and ran rapidly about, stopping frequently to scratch at its mouth. It tumbled about in a most excited manner. Examination showed a tiny mite attached to its labium.

The abnormal movements were undoubtedly efforts to rid itself of the intruder. At that time the weevil did not enlist the sympathies of the writer but it rather gave *him satisfaction to see how its enemies were after it. Later, however, his sympathies* were with the weevil because of the torture it was forced to bear.

Although numerous eggs were deposited on the beans in this container, careful observations showed that only a few adult weevils emerged from them. Upon opening the beans several dead larvae and pupae were found together with numerous large round masses which proved to be gravid female mites. Several of the latter were put into a jar of black-eyed cowpeas from which many weevils were emerging. While the actions of the weevils showed that the mites were busy, several hundred eggs were deposited before the last weevil died.

When the dead weevils were removed from the jar many were carrying gravid female mites protruding from under their wings. The following day the writer broke out with a case of "small-pox," this being the best description for the many pustules on his arms and body. Some days later, after again handling the mites, he experienced a

recurrence of fiery, itching dermatitis. About that time a collaborator complained that he would have to get treatment for a terrible itch with which he said the cooties in the trenches in France were tame in comparison.

The mites multiplied rapidly, killing some of the larvae and many of the pupae of the following generation of beetles and the weevils that did emerge were immediately attacked by great numbers of mites and were killed within a few hours. Vigorous, uninfested females of *B. quadrimaculatus* when placed in this jar were, in some instances, dead within two hours and none were able to survive twenty-four hours. *B. obtectus* Say, however, fared better when put into the same jar. They were able to rid themselves of the mites by using their mouth-parts as a comb through which they drew their legs and antennae, which were thus cleaned of mites, and these in turn were used for brushing their bodies. The mites were killed but not eaten. Of thirteen *B. obtectus*, five survived more than twenty-four hours.

It was while examining the dead weevils inside the beans that the writer became well covered with those minute disseminators of intolerable fiery pustules. One hundred eighteen pustules were scattered about on his person at one time and it was then that his sympathies were with the weevils. The mites completely prevented the emergence of another generation of weevils. According to Dr. Ewing, the mites are probably *Pediculoides ventricosus* Newp.

A. O. LARSON,
Scientific Assistant, Alhambra, California.

Hawaiian Sugar Cane Borer in Costa Rica—A Correction. In my note on some insect pests of Costa Rica, published in this JOURNAL (vol. 12, No. 3, p. 269) I committed a grave error in reporting *Rhabdocnemis obscura* from Zent, C. R. It should have been the Banana Root Borer, *Cosmopolites sordidus* Germ. The error was due in confusing *C. sordidus* with *Metamasius hemipterus*. I am indebted to Dr. E. A. Schwarz for the correct identification. The Banana Root Borer is also quite abundant in Panama and the Canal Zone, together with *Metamasius sericeus* Oliv.

JAMES ZETEK.

Zeitschrift für angewandte Entomologie. Information received through Dr. L. O. Howard discloses the necessity of securing a large number of American subscribers if the *Zeitschrift* is to continue. There are now relatively few complete sets, volumes i-vi with "Beihefte," available. The price of the complete series is $16.00. It may be secured through Prof. K. Escherich, Forschungsinstitut für angewandte Zoölogie, Munchen, Germany.

Tree Hoppers and Alfalfa. Young orchards in Michigan have recently been suffering severely from the attacks of one of the tree hoppers, presumably *Ceresa bubalis*, the injury being perpetrated in the autumn when the eggs are laid on young apple trees of the first or second year. Observations made within the past few weeks have shown that, at least in the majority of cases if not in all of them, this injury has occurred in young orchards set out in alfalfa, one orchard in the southern part of the state was set half in alfalfa and the other half in plowed ground with the result that the latter half was entirely free, while the part of the orchard in the alfalfa was very badly infested,—the eggs being so thickly distributed in the young twigs that many of the trees will be deformed. Following this observation Mr. R. M. Hain, extension specialist in this department, visited the region in question and reports that in every case where severe injury from tree-hopper attacks have occurred, that young trees have been set out in alfalfa, while young trees in the same region not set in alfalfa ground appear to have escaped with slight if any injury. This would seem at first to be rather more than mere coincidence.

R. H. PETTIT,
Entomologist of Experiment Station, Michigan Agricultural College.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1920

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photoengravings may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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The complexity of nature and the many interrelations existing between animals and plants and between many representatives of both major and minor groups in both kingdoms, renders exhaustive investigation and the reaching of well defined conclusions a matter of great difficulty. There has never been more need of solving scientific questions than at the present because of the more or less direct bearing they have upon increased production and the national welfare. The problem of the permanent pasture recently discussed by Professor Herbert Osborn before the Society for the Promotion of Agricultural Science, is only one of many demanding expert knowledge in widely varied lines before it can be answered in a satisfactory manner. Entomology is one of the special sciences and insects frequently play a most important part in inhibiting, sometimes in promoting, greater production, and here and there insects react upon other groups and are in turn reacted upon. The solution of a general problem such as that mentioned above is proportional to our knowledge of the least understood group exercising a vital influence upon the environment. There is need, as pointed out by Professor Osborn, for a more comprehensive, better coördinated study in the case of general problems. Such work may be conducted under the direction of a well recognized authority along general lines, capable of bringing to his aid such expert assistance as may be necessary or the same end may be attained by the specialist seeking the coöperation of others and arranging for a harmonious prosecution of all necessary special studies in relation to the general problem. There are a limited number of the former group at liberty to undertake the supervision of new lines of study and comparatively few individuals in this class are in a position to appreciate the significance

of certain facts with the same force as the specialist. On the other hand, it is not always easy to find a specialist with a breadth of training and experience which makes him capable of appreciating the coördinate value of related lines. Nevertheless, consideration for human welfare demands the solution of many problems and it behooves official agencies to endeavor to meet this need more fully by inaugurating comprehensive and well coördinated investigations for the solution of some of the more pressing general problems. It is quite possible that the National Research Council can perform a most valuable function in determining possibilities along these lines and work out one or more feasible methods of coördinated study and thus assist in utilizing to better advantage the numerous scientists and scientific agencies scattered throughout the country.

Current Notes

Dr. L. O. Howard sailed for Europe May 15.

Mr. J. L. Horsfall has recently been appointed instructor in Economic Entomology at the Pennsylvania State College.

Prof. T. D. A. Cockerell and Mrs. Cockerell expect to sail for England July 10 and will not return to Boulder until August, 1921.

Mr. R. N. Chrystal of the Entomological Branch, Canadian Department of Agriculture, who has recently been ill, is now in England.

Word has just been received that Mr. Richard Helms, Sydney, New South Wales, Australia, a foreign member of this association, died a few years ago.

Dr. H. C. Wood, formerly professor in the Medical School of the University of Pennsylvania, and a student of the Myriapoda, died January 3, 1919.

Mr. R. W. Leiby, assistant Entomologist of the North Carolina Agricultural Experiment Station is secretary-treasurer of the North Carolina Academy of Science.

Mr. C. P. Clausen of the Bureau of Entomology, who was recently appointed to undertake a study of the parasites of the Japanese beetle is now in Japan for that purpose.

Mr. F. C. Bishop, of the Bureau of Entomology, recently made a trip to various counties in New York for the purpose of investigating the ox warble fly situation in that state.

Mr. T. H. Jones of the Bureau of Entomology, has completed a preliminary survey of the entomological situation at Fort Myers, Fla., and has resumed his work at Baton Rouge, La.

Messrs. F. M. Chipman, brown-tail moth survey, and L. M. How, Annapolis Laboratory, have resigned from the Entomological Branch, Canadian Department of Agriculture.

Miss Emily L. Morton, a student and artist, who worked on the Lepidoptera with Dr. A. S. Packard, W. H. Edwards and others, died at her home, New Windsor, N. Y., January 8, 1920.

Mr. E. R. Barber, Bureau of Entomology, expects to return to Cuba shortly for the purpose of collecting and shipping to this country parasites of the sugar-cane moth borer. The results of his shipments in 1919 have been so promising that the Louisiana

Sugar Planters' Association has provided four assistants to accompany Mr. Barber to Cuba this year. This insures an increased supply of the parasites for colonization in the Louisiana cane fields.

A number of shipments of nursery fruit stocks received from France this spring and consigned to different points in the United States and Canada, have been found infested with the brown-tail moth.

Mr. C. C. Hamilton, Columhia, Mo., has recently accepted a position as assistant entomologist at the Maryland Agricultural Experiment Station. He will be engaged in research on the Adams fund basis.

The Bureau of Entomology has discontinued its lahoratory maintained at Seaview, Wash., in coöperation with Washington Agricultural College, where important problems relative to Cranberry insects have been solved.

Professor R. C. Osburn and Dr. C. H. Kennedy of Ohio State University are members of the staff of the Lake Laboratory, which is now permanently located at Put-in-Bay on Lake Erie, and its summer session will open on June 21 and close August 1.

Mr. E. R. Van Leeuwen of the Bureau of Entomology, who has been temporarily in Washington, has recently been placed in charge of the Bureau's laboratory at Cornelia, Ga., where life history studies of the codling moth in that region will be made.

Dr. H. M. Parshley of Smith College, Northampton, Mass., will again conduct field courses during July and August, at the thirty-first session of the Biological Laboratory of the Brooklyn Institute of Arts and Sciences, at Cold Spring Harbor, Long Island, N. Y.

Dr. C. J. S. Bethune, Professor of Entomology, Ontario Agricultural College, Guelph, Ontario, was elected a Fellow Emeritus "in recognition of his long and faithful membership," hy the Council at the St. Louis meeting of the American Association for the Advancement of Science.

Mr. Claude Wakeland, Deputy State Entomologist of Colorado in charge of alfalfa weevil investigation during the three years 1917-19, has accepted the position of State Extension Entomologist with the University of Idaho. Mr. Wakeland's permanent headquarters will be at Boise, Idaho.

Messrs. J. W. Sauer and J. M. Reilly, entomological inspectors in Texas, and W. M. Mingee, W. H. Carpenter, and L. M. Pritchard, field assistants in insect control, have severed their connection with the Bureau of Entomology. The last three will be connected with the Mississippi State Plant Board.

Mr. E. H. Strickland, of the Entomological Branch, Canadian Department of Agriculture, recently visited St. Paul and Minneapolis to confer regarding stored product insects, and also arranged coöperative experiments with the members of the staff of the University of Minnesota on the control of cutworms.

Professor Vernon L. Kellogg, Stanford University, California, has been elected a member of the American Philosophical Society. According to *"Science"* Professor Kellogg recently addressed the New York Alumni Society of the Phi Beta Kappa, and also the Washington Academy of Sciences, on "Europe's Food in War and Armistice."

The State College of Washington has recently acquired the entire collection of Dr Oliver S. Westcott, the veteran entomologist of Chicago, who died last July. Dr Westcott for sixty-eight years was actively engaged in amassing this collection. It contains hetween forty and forty-five thousand mounted specimens. The insects of his earlier years were determined by such specialists as Ashmead, Edwards, Leconte, Horn, Ulke, and Uhler. Every state in the Union is represented hy insects personally

caught by Dr. Westcott. The collection of Mexican and South American butterflies is particularly interesting.

A plan for closer affiliation between the College of Agriculture of Ohio State University, and the Agricultural Experiment Station has been put into effect. Professor Herbert Osborn, of the university has been made honorary associate entomologist of the station and Professor H. A. Gossard, chief entomologist of the station has been appointed non-resident professor of entomology in the college.

Recent appointments to the Entomological Branch, Canadian Department of Agriculture, are announced as follows:—Mr. Eric Hearle, assistant entomologist, Mission, B. C.; Mr. V. B. Durling, temporary junior entomologist, Annapolis laboratory; Mr. Andrew Galbraith, temporary superintendent of fumigation, Windsor, Ont.; Miss M. McNair, temporary junior clerk-stenographer, Fredericton Laboratory.

Dr. E. G. Titus, for three and one-half years technologist in charge of the intermountain section, sugar plant investigations, Bureau of Plant Industry, and formerly entomologist of the Utah Experiment Station, has recently accepted a position as director of agricultural research of the Utah-Idaho Sugar Co., with headquarters at Salt Lake City, Utah. His efforts will he engaged along the lines of seed breeding, pest control and general improvements in the growing and handling of sugar beets.

Officers of the Entomological Society of America were elected at the St. Louis meeting as follows: President, L. O. Howard; First Vice-President, F. E. Lutz; Second Vice-President, Edith M. Patch; Secretary-Treasurer, J. M. Aldrich. Additional members Executive Committee: W. S. Marshall, G. A. Dean, J. W. Folsom, G. W. Herrick. Committee on Nomenclature: E. P. Felt, T. D. A. Cockerell, Nathan Banks. Committee on Entomology in the National Museum: C. W. Johnson, Herbert Osborn, Wm. Barnes, W. M. Wheeler, J. G. Needham.

A conference was held at the Japanese beetle laboratory, Riverton, N. J., May 14, to consider certain phases of the quarantine regulations to prevent the spread of the Japanese beetle. There were present the following entomologists and officials engaged in pest control from New Jersey and surrounding states and the United States Bureau of Entomology:—Dr. A. L. Quaintance, Washington, D. C.; Professor E. N. Cory, College Park, Md.; Professor J. G. Sanders, Harrisburg, Pa.; Mr. Wesley Webb, Dover, Del.; Dr. G. G. Atwood, Albany, N. Y.; Dr. W. E. Britton, New Haven, Conn.; Dr. T. J. Headlee, Messrs. John J. Davis, C. H. Hadley, Harry Weiss, C. W. Stockwell and other assistants, New Jersey.

A change has been made recently in the plant quarantine service of Porto Rico. Mr. E. G. Smyth, entomologist of the Insular Experiment Station and the island Department of Agriculture, who has been in charge of quarantine work for the past three years, has given up the work, and a technical board of plant quarantine has been appointed hy the Commissioner of Agriculture and Labor of the Island, which is empowered to determine procedure as to quarantine matters. The board consists of four members: the director, the entomologist and the pathologist of the experiment station at Rio Piedras, and the chief quarantine inspector in San Juan.

Entomological workers in Louisiana have formed an organization to be known as the Louisiana Entomological Society. The domicile of the society will be the Natural History Building of the Louisiana State Museum, Jackson Square, New Orleans. The first president is Mr. Ed. Foster, State Nursery Inspector, who was largely instrumental in hringing the members together. Prof. O. W. Rosewall, professor of entomology at the Louisiana State University, has been elected vice-president, and T. E. Holloway, is secretary-treasurer. Meetings will he held on the first Fridays of

February, April, June, October and December, and visiting entomologists are cordially invited to attend. The society starts with twenty-five members. The membership is open to any person interested in the science of entomology.

Mr. J. S. Woodard is assistant entomologist of the Texas State Department of Agriculture, Austin, Texas.

Mr. F. F. Baird, who was engaged in spruce bud moth investigations, entomological branch, Canada Department of Agriculture, resigned April 30.

According to *Science*, Dr. Cornelius Betten, secretary of the State College of Agriculture, Cornell University, has been appointed vice-dean of the college.

The Berkeley, Cal., laboratory of the Bureau of Entomology has been transferred to Sacramento, where it will be in charge of Mr. C. M. Packard, with B. G. Thompson as scientific assistant, and Margaret Marshall as clerk.

The laboratory of the Bureau of Entomology, which has been conducted at Hagerstown, Md., was discontinued April 1, and the work transferred to Charlottesville, Va., where it will be under the direction of Mr. W. J. Phillips.

Mr. Hall B. Carpenter, formerly of the corn borer and the pink cotton boll weevil work of the Federal Bureau of Entomology has entered the New York state service as special assistant in corn borer work, with headquarters at Schenectady, N. Y.

Mr. W. V. Becker, who has recently been connected with the Pennsylvania State Department of Health, in charge of mosquito suppression work, has recently resigned to accept a similar position with the health department of the city of Philadelphia.

Mr. S. T. Sealy, formerly of the Nassau County, N. Y., mosquito extermination force, has been appointed deputy in charge of mosquito control work for Connecticut, and entered upon his duties April 19. His headquarters are at the Agricultural Experiment Station, New Haven.

Transfers in the Bureau of Entomology have been made recently as follows: M. C. Lane, Forest Grove, Ore., to Ritzville, Wash.; W. B. Cartwright, Knoxville, Tenn., to West Lafayette, Ind.; Charles H. Gable, Tempe, Ariz., to San Antonio, Tex.; B. G. Thompson, Forest Grove, Ore., to Sacramento, Cal.

Canada has recently enacted regulations prohibiting the importation of alfalfa hay for feeding, packing, or other purposes from Idaho, Utah, and from Uintah, Sweetwater, and Lincoln counties in Wyoming, and Dennison and Gunnison counties in Colorado, on account of the danger of transporting the alfalfa weevil.

Mr. Harry F. Dietz, who was formerly connected with the Federal Horticultural Board and the Bureau of Entomology, as an entomological inspector, has accepted the position of assistant entomologist with the Department of Conservation, Division of Entomology, of the state of Indiana, with headquarters at Indianapolis, Ind.

Dr. W. Dwight Pierce announces the merger of The Gage-Pierce Research Laboratories with the United Reduction and Metal Company of Denver to form The Mineral, Metal and By-Products Company. Dr. Pierce is managing director of the Biological Department. The offices of the company are Suite 308, Continental Trust Building, Denver. Entomologists visiting Denver are cordially invited to call.

Dr. Oliver S. Westcott, principal of the Waller High School, died July 31, 1919, in his 85th year. Dr. Wescott was an entomologist and collected insects in nearly all parts of the United States, Canada, Alaska, Mexico, Cuba and Hawaii. His insect collection of about 45,000 specimens has been purchased by the State College

at Pullman, Washington, and his library was sold to John Sherman, Jr., Mount Vernon, N. Y. Dr. Wescott published several notes in *Entomological News*.

Recent appointments to the U. S. Bureau of Entomology have been announced as follows:—Cereal and forage crop insect investigations, Herbert Walkden, Wichita, Kans.; Kenneth M. King, Charlottesville, Va.; Ralph A. Blanchard, West Lafayette, Ind.; H. N. Bartley, E. G. Brewer, J. W. Enright, T. R. Richardson, Saul Phillips; Claude E. Towle, L. B. Sanderson, Dexter H. Craig, Arlington, Mass.; E. M. Searls, Schenectady, N. Y.

Mr. D. B. Young, assistant state entomologist of New York, has been temporarily detailed in charge of special field investigations of the European corn borer and study of control methods provided for in a supply bill item of $5,000 appropriated by the New York State Legislature. The work will be in coöperation with and supplemental to the investigations being conducted at the U. S. Bureau of Entomology corn borer laboratory located at Schenectady, N. Y.

According to *Science*, Dr. W. M. Wheeler, Dean of Bussey Institution of Harvard University, delivered an address at Syracuse University, May 6, under the auspices of the Society of Sigma Xi. The address was on "Worm-lions, Ant-lions and some Eighteenth-Century Entomologists," and covered observations made by Réaumur and other early naturalists upon the habits of the worm-lion and ant-lion, and included the studies of the lecturer upon the structure and behavior of the worm-lions of California.

The following appointments to the entomological branch, Canada Department of Agriculture, have been announced: Mr. H. G. Crawford, entomologist, field crop and garden insects, Ottawa; temporary seasonal assistants, Mr. E. P. Donat, Annapolis, N. S.; Mr. E. P. Venables, Vernon, B. C.; Mr. R. Glendenning, Agassiz, B. C.; Mr. J. G. Arnason, Lethbridge, Alta.; Mr. A. M. Crawford, Mission, B. C.; Mr. R. N. Bissonnette, Ottawa; Mr. J. A. Clock has been appointed temporary junior entomologist at Strathroy, Ont., and Mr. V. C. Smith, temporary messenger at Ottawa.

Dr. W. M. Mann, of the Bureau of Entomology, has just returned from a month's trip of exploration in Spanish Honduras, where he went to obtain a first-hand knowledge of the fruit-fly and other insect pest conditions in that country on account of the active commerce in fruits and other products, which is now going on between Spanish Honduras and the United States, principally through the port of New Orleans. Some six vessels arrive at New Orleans weekly from Spanish Honduras, bringing bananas, chiefly, but also citrus fruit, egg-plant, and miscellaneous fruits. Dr. Mann has already bred out no less than four different species of fruit flies from material collected, and in addition to that has notes and specimens illustrating a good many other fruit insects of greater or lesser importance.

Mr. U. C. Loftin, of the Bureau of Entomology, was commissioned early in the year, to make an investigation of the insect pests of cotton in Porto Rico, more particularly to determine if it is advisable to permit Porto Rican cotton seed to enter the United States for milling. In the course of this work he also investigated the cotton situation in San Domingo, at the request of the San Domingo government. No pink bollworm was found either in Porto Rico or in San Domingo, but a large list of other cotton insects, most of them well-known enemies of this plant were collected. A cotton blister mite, was found, which is not known to occur in the United States; and the occurrence also of certain cotton diseases in the Island, notably an internal boll disease, which seems to be widely distributed through the West Indies and prob-

ahly new to the United States, would seem to indicate the undesirability of allowing the cotton seed to come into this country.

Some twenty-four boxes of parasitic material for use in the corn borer investigations arrived at the port of New York during the week of April 4. This material was shipped from Bordeaux, France, by W. R. Thompson of the Bureau of Entomology, who is in charge of a laboratory which has been established at Auch, Gers, France, for the purpose of studying and collecting the European parasites of *Pyrausta nubilalis*. This material was immediately trans-shipped to Boston in charge of Harry L. Parker, and the primary parasites emerging from it very prohably will be liberated in suitable areas in eastern Massachusetts during the next few weeks.

The first annual conference of entomological workers in North Carolina was held in Room 21, Animal Husbandry Building, North Carolina State College, April 17, 1920, at 2.30 p. m. The following program was presented:

The Work of the Division of Entomology, Department of Agriculture and State Experiment Station. By Franklin Sherman.

The Work of the Department of Zoölogy and Entomology, State College and Experiment Station. By Z. P. Metcalf.

Discussion of Projects: Corn Stalk-borer and other projects. By R. B. Leiby.
Homoptera and other projects. By Z. P. Metcalf.
Cotton Boll Weevil and other projects. By F. Sherman.
Insect Survey and other projects. By C. S. Brimley.
Corn Root Worm and other projects. By Mr. Spencer.
Household Insects. By Mr. Haber.
Bee-keeping Extension Work. By C. L. Sams.
Nursery Inspection. By J. E. Eckert.
The English Sparrow. By Dr. Williams.
Extension Work in Entomology. By Mr. Smith.

LOUISIANA ENTOMOLOGICAL SOCIETY

A meeting of entomologists was called at New Orleans on March 5 to consider the formation of an entomological society or cluh. The meeting was attended by ten persons interested in entomology, including two from Baton Rouge, and it was decided to form The Louisiana Entomological Society.

The first regular meeting of the society was held on April 2 at the Natural History Building, Louisiana State Museum, Jackson Square, New Orleans. A constitution and hy-laws was adopted, and the following officers were elected: President, Mr. Ed. Foster; Vice-President, Mr. O. W. Rosewall; Secretary-Treasurer, Mr. T. E. Holloway. The Executive Committee is composed of the officers with the addition of Messrs. O. K. Courtney, Charles E. Smith and T. H. Cutrer.

Any person interested in entomology, whether a resident of Louisiana or not, is eligihle for membership. The present membership consists of about twenty-five people.

T. E. Holloway,
Secretary-Treasurer.

Mailed June 28, 1920.